Dissertation on

A STUDY OF RADIAL ARTERY, ITS BRANCHING PATTERN AND VARIATIONS WITH CLINICAL APPLICATIONS

Submitted in partial fulfillment for

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BRANCH- XXIII, ANATOMY

Upgraded Institute of Anatomy
Madras Medical College & Rajiv Gandhi Government General Hospital,
Chennai - 600 003

THE TAMILNADU Dr.M.G.R. MEDICAL UNIVERSITY
CHENNAI – 600 032
TAMILNADU

APRIL-2016

CERTIFICATE

This is to certify that this dissertation entitled

"A STUDY OF RADIAL ARTERY, ITS BRANCHING PATTERN AND VARIATIONS WITH CLINICAL APPLICATIONS"

is a bonafide record of the research work done by **Dr. KEERTHI.S**, Post graduate student in the Institute of Anatomy, Madras Medical College and Rajiv Gandhi Government General Hospital,Chennai-03, in partial fulfillment of the regulations laid down by The Tamil Nadu Dr.M.G.R. Medical University for the award of M.D. Degree Branch XXIII-Anatomy, under my guidance and supervision during the academic year from 2013-2016.

The Dean,
Madras Medical College &
Rajiv Gandhi Govt. General Hospital,
Chennai
Chennai – 600003.

Dr. Sudha Seshayyan,
M.B.B.S., M.S.,
Director & Professor,
Institute of Anatomy,
Madras Medical College,
Chennai– 600 003.

INSTITUTIONAL ETHICS COMMITTEE
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EC Reg No.ECR/270/Inst./TN/2013
Telephone No. 044 25305301
Fax : 044 25363970

CERTIFICATE OF APPROVAL

To
Dr. S.Keerthi
Postgraduate M.D.(Anatomy)
Madras Medical College
Chennai – 600 003.

Dear Dr. S.Keerthi,

The Institutional Ethics Committee has considered your request and approved your study titled **"A study of Radial artery, its branching pattern and variations with clinical applications". No.22122014.**

The following members of Ethics Committee were present in the meeting held on 02.12.2014 conducted at Madras Medical College, Chennai-3.

1. Dr.C.Rajendran, M.D.,	: Chairperson
2. Dr.R.Vimala, M.D., Dean, MMC, Ch-3	: Deputy Chairperson
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11. Thiru S.Govindasamy, B.A., B.L.,	: Lawyer
12. Tmt.Arnold Saulina, M.A., MSW.,	: Social Scientist

We approve the proposal to be conducted in its presented form.

The Institutional Ethics Committee expects to be informed about the progress of the study and SAE occurring in the course of the study, any changes in the protocol and patients information/informed consent and asks to be provided a copy of the final report.

MEMBER SECRETARY
INSTITUTIONAL ETHICS COMMITTEE
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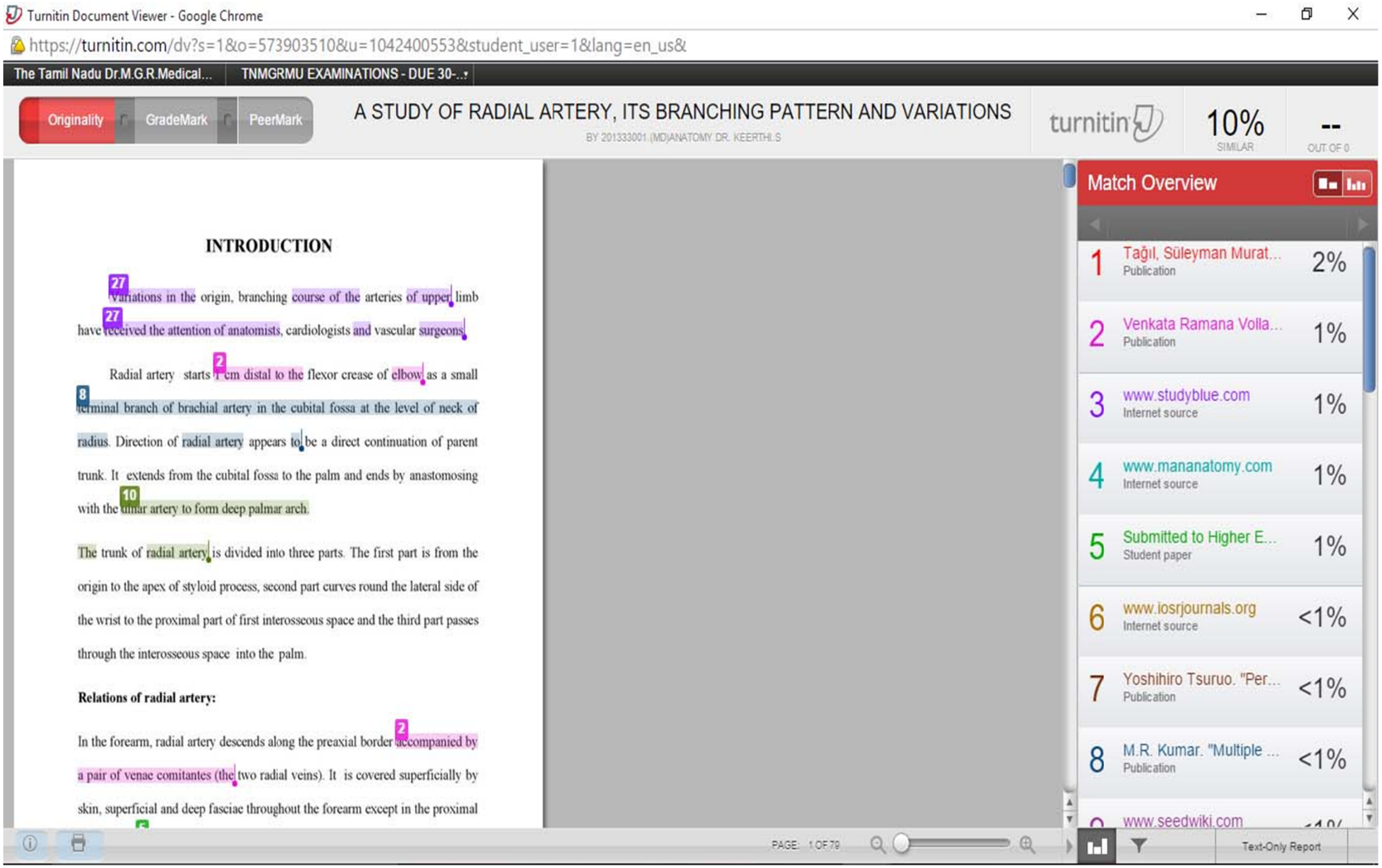
Member Secretary, Ethics Committee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INTRODUCTION
Variations in the origin, branching course of the arteries of upper limb have received the attention of anatomists, cardiologists and vascular surgeons.
Radial artery starts 1 cm distal to the flexor crease of elbow as a small terminal branch of brachial artery in the cubital fossa at the level of neck of radius. Direction of radial artery appears to be a direct continuation of parent trunk. It extends from the cubital fossa to the palm and ends by anastomosing with the ulnar artery to form deep palmar arch.
The trunk of radial artery is divided into three parts. The first part is from the origin to the apex of styloid process, second part curves round the lateral side of the wrist to the proximal part of first interosseous space and the third part passes through the interosseous space into the palm.
Relations of radial artery:
In the forearm, radial artery descends along the preaxial border accompanied by a pair of venae comitantes (the two radial veins). It is covered superficially by skin, superficial and deep fasciae throughout the forearm except in the proximal
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I thank my parents and parents in law who have showered their choicest blessings on me and supported me in my every step.

I am grateful beyond words to my husband **Mr.Rajesh kumar. R** who in all possible ways supported me in making this study a reality.

Above all, I thank the **Almighty**, who has showered his blessings on me and helped me complete this study successfully.

LEGEND

AA	-	Axillary Artery
AIA	-	Anterior Interosseous Artery
APP	-	Arteria Princeps Pollicis
ARI	-	Arteria Radialic Indicis
BA	-	Brachial artery
CABG	-	Coranory Artery Bypass Graft
CF	-	Cubital Fossa
CIA	-	Common Interosseous Artery
DPA	-	Deep Pal mar Arch
FDMA	-	First Dorsal Metacarpal Artery
HORA	-	High Origin of Radial Artery
MN	-	Median Nerve
PT	-	Pronator Teres
RA	-	Radial Artery
RN	-	Radial Nerve
RRA	-	Recurrent Radial Artery
SPA	-	Superficial Palmar Arch
SPB	-	Superficial Palmar Branch
UA	-	Ulnar Artery
UL	-	Upper Limb

CONTENTS

A STUDY OF RADIAL ARTERY, ITS BRANCHING PATTERN AND VARIATIONS WITH CLINICAL APPLICATIONS

ABSTRACT

The Radial artery is one of the two terminal branches of brachial artery at the level of cubital fossa. Variations in the origin, course and branching pattern of Radial artery are very common and of interest to anatomists and clinicians. Radial artery is being increasingly used for various interventional and investigative procedures like coronary angiography and coronary artery bypass graft (CABG) Knowledge about the origin, course and branches of Radial artery as well as the formation of Superficial and Deep palmar arches is important for vascular and plastic surgeries.

Present study was done to document and provide information of both normal and variant morphology of the radial artery. 25 adult human cadavers (50 Upper limbs) from the Institute of Anatomy, Madras medical College were used for the study.

In the present study it was found that high origin of radial artery from brachial artery in arm was in 6%. The mean length of radial artery was 21.25cms. Recurrent Radial artery arose from the radial artery and brachial artery in 96% and 4% respectively. Accessory recurrent radial artery was present in 4% of specimens.

Superficial palmar arch was complete in 80% and incomplete in 20% respectively. Among the complete arch type I was 40%, type II was 8% and type V was 2%. Among the incomplete arch type I was 4% and type II was 16%.

The data obtained will be useful for cardiovascular surgeons, plastic surgeons and orthopaedic surgeons.

Key words: Radial artery, Brachial Artery, Superficial palmar arch, Deep palmar arch.

INTRODUCTION

Variations in the origin, branching pattern and course of the arteries of upper limb have received the attention of anatomists, cardiologists and vascular surgeons.

Radial artery starts 1 cm distal to the flexor crease of elbow as a small terminal branch of brachial artery in the cubital fossa at the level of neck of radius. Direction of radial artery appears to be a direct continuation of parent trunk. It extends from the cubital fossa to the palm and ends by anastomosing with the ulnar artery to form deep palmar arch[20,58,].

The trunk of radial artery is divided into three parts. The first part is from the origin to the apex of styloid process, second part curves round the lateral side of the wrist to the proximal part of first interosseous space and the third part passes through the interosseous space into the palm.

Relations of radial artery:

In the forearm, radial artery descends along the preaxial border accompanied by a pair of venae comitantes (the two radial veins). It is covered superficially by skin, superficial and deep fasciae throughout the forearm except in the proximal part where it is overlapped by the belly of brachioradialis. Radial artery lies over the tendon of biceps, supinator,

insertion of pronator teres, lateral half of flexor digitorum superficialis, flexor pollicis longus and pronator quadratus from above downwards. Middle 1/3 of artery is related to the superficial branch of radial nerve. Proximally, it runs between the brachioradialis laterally and pronator teres medially, then it passes inferolaterally between the brachioradialis and flexor carpi radialis to reach the anterior surface of the distal end of radius between the tendons of these muscles. Here the radial pulse is felt against the bone.

Second part of the artery curves over the radial aspect of wrist joint, from a point little beyond the styloid process to the first interosseous space. It passes between the lateral carpal ligament and long abductor and short extensor of thumb (in the anatomical snuff box). Here it is related dorsally to the scaphoid and trapezium and is crossed superficially by the commencement of cephalic vein and digital branches of radial nerve. Subsequently it lies superficially.

In the hand, radial artery enters the palm by passing between the two heads of first dorsal interosseous muscle. Then it turns medially, passes between the transverse and oblique head of adductor pollicis and continues its course with a slight forward convexity, across the base of metacarpal bones, joins with the deep branch of ulnar artery to form the deep palmar arch. It lies deep to the long flexor tendons and lumbricals[58].

Branches of radial artery

From first part:

1. Recurrent radial artery arises from the lateral side of radial artery just beyond its origin. It passes between the superficial and deep branch of radial nerve and then ascends posterior to brachioradialis and anterior to supinator and brachialis. It ends by anastomosing with the branches of profunda brachii artery round the elbow joint. It also supplies the muscles around the elbow joint.
2. Cutaneous branches are given off from the artery throughout the forearm. These cutaneous vessels anastomose with the cutaneous branches of ulnar and anterior interosseous artery.
3. Muscular branches to the muscles in the lateral side of forearm
4. Superficial palmar branch is given off at the point where the radial artery curves laterally around the wrist. It courses forwards over the thenar muscles and anastomoses with the similar branch of ulnar artery to complete the superficial palmar arch. Sometimes it ends by supplying the muscles of thumb without forming the arch.

   The superficial palmar arch lies deep to the Palmaris brevis and palmar aponeurosis and superficial to the long flexor tendons and lumbricals, flexor digiti minimi and the branches of median nerve[20].

From second part:

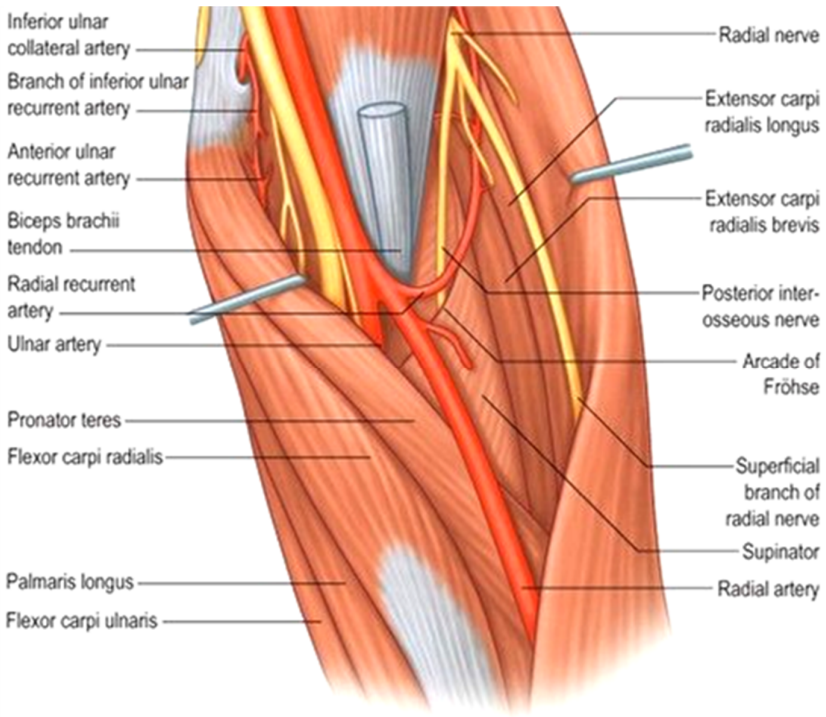
1. Palmar carpal branch is a slender branch given off from the radial artery at the lower border of pronator quadratus. Palmar carpal branch anastomoses with the palmar carpal branch of ulnar artery, anterior interosseous artery and recurrent branches from the deep palmar arch to form the cruciate anastomosis over the anterior aspect of the carpal joint.
2. Dorsal carpal branch is given off from the radial artery deep to the extensor tendons of wrist. It runs medially to anastomose with the similar branch of ulnar artery, anterior and posterior interosseous arteries to form the dorsal carpal arch over the dorsal aspect of the carpal joint.
3. First dorsal metacarpal artery arises from the radial artery just before it passes between the two heads of first dorsal interosseous muscle to supply the adjacent sides of dorsal aspect of the thumb. It follows a fascial course overlying the first dorsal interosseous muscle and parallel to the second metacarpal[20].

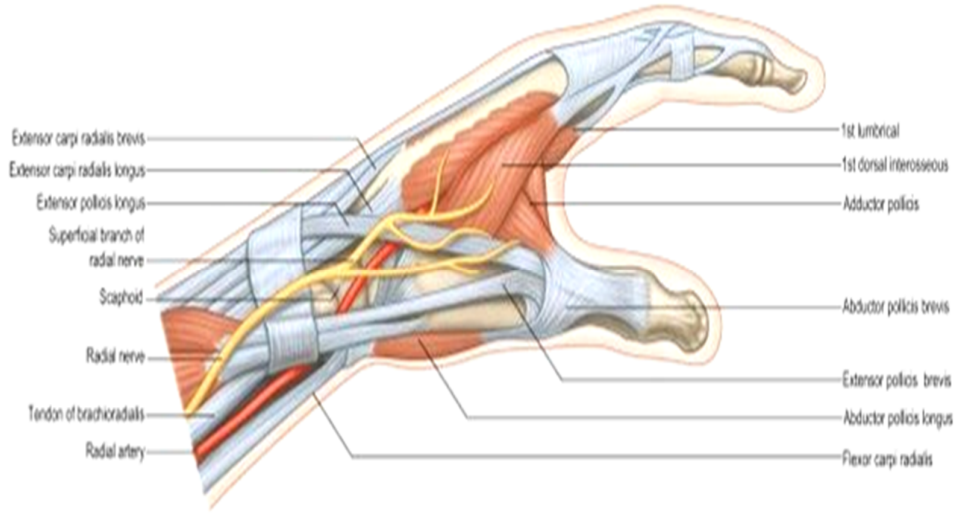
From third part:

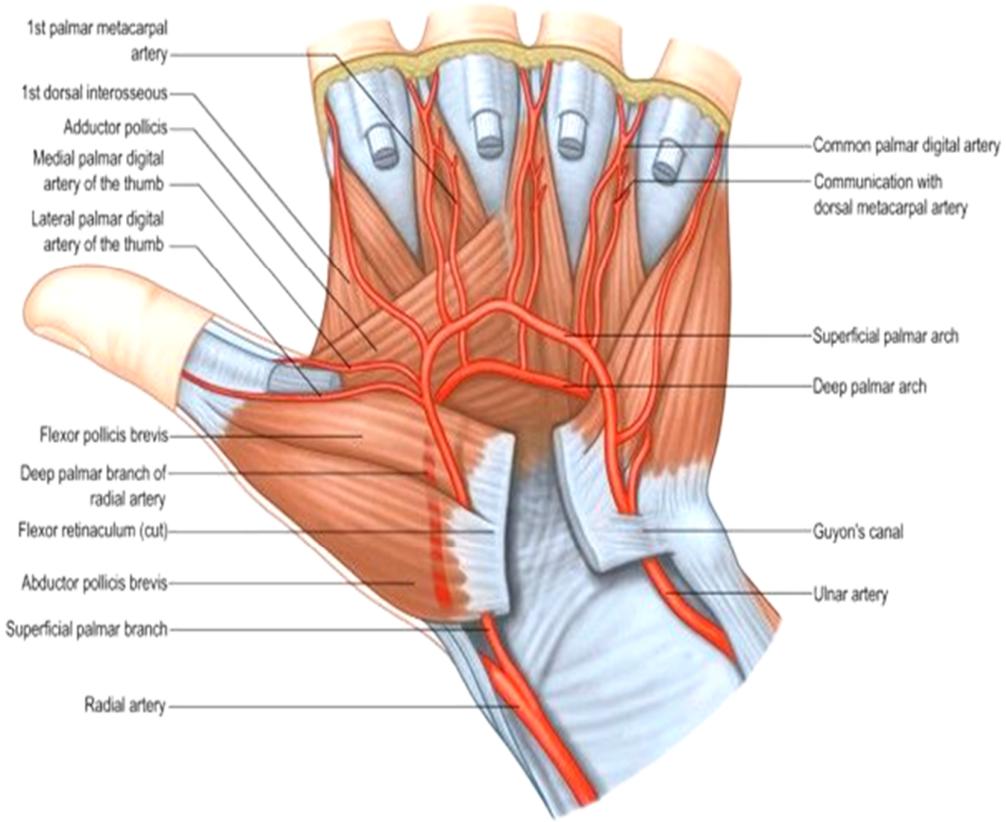
1. Arteria princeps pollicis arise from the radial artery in the palm. Nutrient artery to the first metacarpal bone is a branch of Arteria princeps pollicis.

2. Arteria radialis indicis arises from the proximal part of arteria princeps pollicis. It may arise from the superficial palmar arch or from the first dorsal metacarpal artery[20].

ORIGIN, COURSE AND BRANCHES OF RADIAL ARTERY




Extensor carpi radialis brevis
Extensor carpi radialis longus
Extensor pollicis longus
Superficial branch of radial nerve
Scaphoid
Radial nerve
Tendon of brachioradialis
Radial artery
1st lumbrical
1st dorsal interosseous
Adductor pollicis
Abductor pollicis brevis
Extensor pollicis brevis
Abductor pollicis longus
Flexor carpi radialis


1st palmar metacarpal artery
1st dorsal interosseous
Adductor pollicis
Medial palmar digital artery of the thumb
Lateral palmar digital artery of the thumb
Flexor pollicis brevis
Deep palmar branch of radial artery
Flexor retinaculum (cut)
Abductor pollicis brevis
Superficial palmar branch
Radial artery
Common palmar digital artery
Communication with dorsal metacarpal artery
Superficial palmar arch
Deep palmar arch
Guyon's canal
Ulnar artery

Aim of the study

AIM OF THE STUDY

Radial artery is used for a number of clinical investigations and interventions. Some of the important ones are discussed below.

The radial artery is relatively superficial throughout its course in forearm and easily accessible for catheterisation. Hence it can be used for investigations related to coronary artery and also interventions like invasive coronary angioplasty and associated stenting.

Though the radial artery is superficial throughout its course, it has bony relation at the lower part of forearm, where it lies over the distal end of radius. The clinicians make use of this to examine the arterial pulse.

The radial artery at the distal part of forearm is a convenient site for collection of arterial blood samples.

Histology and size of radial artery is similar to that of coronary artery and post Coronary Artery Bypass Graft (CABG) atherosclerosis of radial artery is less compared to other grafts. Also the rate of acceptance of graft is more. Hence, nowadays radial artery is preferred over saphenous vein by the cardiologists for CABG.

The radial artery graft is used in extracranial bypass of maxillary artery with the second part of middle meningeal artery.

The fasciocutaneous branches of radial artery provide the anatomical basis for skin flap harvested from the lateral aspect of forearm. The flap can be either used as a free flap or pedicle flap based on radial artery and its venae comitantes. Pedicle flap is used for the reconstruction of oral mucosa.

The vascularity of radius by the muscular branches of radial artery is an important factor when it is used in reconstruction of mandible.

Autogenous arteriovenous fistula (radial artery with the veins of forearm) is made for patients who need long term renal dialysis.

Knowledge about the recurrent radial artery is essential for orthopaedicians and plastic surgeons as the recurrent radial artery based flap can be used for reconstruction around elbow with good survival rate.

The first dorsal metacarpal artery based flap can be used for the reconstruction of thumb after injury.

Knowledge about the formation of palmar arches and the contribution of radial artery in completing the arch is important before

harvesting the graft for CABG, otherwise it may lead to ischemia of hand. It is also important in microsurgical hand reconstructive surgeries.

Knowledge about the course of radial artery is essential for the orthopaedic surgeons. High origin of radial artery with superficial course in arm is more vulnerable to accidental injury and it can be mistaken for vein and ligated during surgeries on humerus.

The anomalous course of radial artery in the cubital fossa can be mistaken as vein and any accidental injection of drugs may lead to spasm of the vessel and gangrene of hand.

As the radial artery and its branches have wide clinical applications, it is mandatory to know the normal course and branching pattern of radial artery and variations present if any, before proceeding with any diagnostic or interventional procedure.

Parameters:

1. Site of origin of radial artery
2. Length of radial artery
3. Course of radial artery

4. Branches of radial artery
    a) Recurrent radial artery
        - Origin
        - Presence of accessory recurrent radial artery
    b) Superficial palmar branch
        - Mode of termination
    c) Origin of arteria princeps pollicis and arteria radialis indicis
    d) Orign of palmar carpal branch
    e) Origin of dorsal carpal branch
    f) Origin of 1st dorsal metacarpal artery
    g) Any other variations in branches
5. Completion of superficial palmar arch by radial artery
6. Formation of deep palmar arch by radial artery

Review of Literature

REVIEW OF LITERATURE

1. ORIGIN OF RADIAL ARTERY

George A Piersol [20](1930) has stated that RA is one of the two terminal branches of BA and arises at the level of elbow bend.

Thomas Walmsley[60] (1934) has described that RA appears to be a direct continuation of BA and is smaller than the UA.

J E Frazer[17] (1937) has described that BA terminates in the CF opposite to neck of radius by dividing into RA and UA. Also described RA is smaller than UA and its direction appears to be direct continuation of BA.

C Latimer Callander, Dean Lewis[8] (1939) has stated that RA arises from the BA at the level of the neck of radius.

J Parsons Schaeffer[39] (1942) has quoted that RA is smaller than UA and appears as a direct continuation of BA.

G J Romanes[18](1964) in the book 'Cunninghams textbook of anatomy' has described that RA arises from the BA and it is in more direct line with the parent trunk. Also stated that RA may be absent and its place being taken by branches of UA or anterior interosseous artery.

W Henry Hollinshead[23](1969), in his book "Text Book of Anatomy" has stated that RA normally arises as the lateral terminal branch of BA in the CF accompanied by two radial veins.

Suganthy J et al[53] (2002) in a case reported that RA was absent in the right upper limb and its territory in forearm was supplied by the anterior interosseous artery, which contributes the formation of deep palmar arch.

Omer Faruk Dogan et al[37] (2004) studied RA in 12 patients who underwent CABG and observed the absence of RA and UA in 1 patient, with persistence of median artery.

Susan Standring[58](2008) has stated that RA arises from the Brachial Artery(BA) 1cm below the elbow crease.

Chandini gupta et al[9] (2012) studied the anatomy of RA in 75 cadavers and observed that RA arose from the BA in CF in 94.8% (71 cadavers).

Nasr Y[34] (2012) studied the anatomical variations of RA in 50 UL specimens, noted that RA arose from the BA in CF in 84%.

Sharadhakumar[47] (2013) in his study on BA in 100 cadaveras(200 upper limbs) observed that 86% RA arose from BA in CF.

Prakash et al[40] (2014) studied the morphology of RA in 50 specimens and observed that RA arose from the BA in CF in all the specimens.

Nitin R Mudiraj et al[35] (2015) studied RA in 90 upper limbs, found that 86.6% of RA arose from the BA in CF.

HIGH ORIGIN OF RADIAL ARTERY (HORA)

Thomas Walmsley[60] (1934) has stated that RA may arise from the AA or proximal part of BA.

J E Frazer[17] (1937) in his book Manual of Anatomy stated that RA may arise from the AA or upper part of BA, associated with superficial course of RA.

G J Romanes[18] (1964) in the book 'Cunninghams textbook of anatomy' has stated RA may arise from the axillary artery or from the BA in arm.

Ernest Gardner, Donald J gray, R O'Rahilly[15] (1967)in their book "A Regional Study of Human Structures" stated that RA may be occasionally absent, or it may arise from BA in arm or from AA in axilla.

W Henry Hollinshead[23](1969), in his book Anatomy for Surgeons quoted that in the work done by McCormack et al, the RA arose

from the AA in 2.13% and from BA in arm in 12.14%. Also stated that HORA is sometimes associated with a communicating branch of RA passing in front or behind the tendon of biceps to reach the BA in CF.

Baral P et al[4] (2002) studied the arterial system of UL specimens in 102 UL specimens, found that in 4.9 % cases RA arose from BA.

Omer Faruk Dogan et al[37] (2004) in his study of CT angiograms of 32 patients planning to undergo CABG with RA graft, found that HORA was present in 1 patient.

C Pelin et al[7] (2006) reported a case of origin of RA from BA, 12cm above the intercondylar line.

Susan Standring[58] (2008) has stated that sometimes RA arise from axillary artery or from BA in arm.

Madhyastha et al[30] (2009) in a case report stated that RA arose from BA, 4cm distal to the lower border of teres major.

Ileana Dinea et al[24] (2010) dissected 14 UL specimens, observed that HORA from BA in middle 1/3 of arm in one specimen(7.14%).

Harbans singh et al[22] (2010) during their dissection, observed a case of unilateral HORA from BA, about 10.5cm above the intercondylar line.

Swaroop N et al[59](2011) reported a case of HORA from BA , which passes between the two divisions of median nerve. Also observed a communicating branch from RA to UA in CF.

Chandini gupta et al[9] (2012) studied morphology of RA in 75 cadavers, reported the HORA in 5.32%, in which 2.66% of RA arose from AA and 2.66% arose from BA, 16 cm above the intercondylar line.

Nasr A Y[34] (2012) in their study on RA, observed HORA in 16% of specimens.

Shiny et al[49] (2013) reported a case of HORA from third part of AA, proximal to the formation of median nerve.

Jayasabarinathan et al[25](2013) in a case report stated that RA arose from the upper part of BA, below the lower border of teres major.

Sharadhakumar[47] (2013) studied the BA in 200 cadavers, found HORA in 13%.

Shubha R et al[51] (2013) studied the bifurcation of BA in 69 UL specimens, noted that 10.1% (7/69) of RA had high origin from BA.

Chandrika Teli et al[13](2013) reported a case of HORA from BA, about 1.5 cm distal to the lower border of teres major. In forearm, RA followed the usual course.

Priya S patil et al[41] (2004) reported a case of HORA from first part of AA, associated with Recurrent Radial Artery(RRA) arising from BA .

Padma Varlekar et al[38] (2013) dissected 96 upper limbs, observed HORA in 3.12% of specimens.

Li L et al [29](2013) observed origin of RA in 1400 patients who underwent transradial coronary angiogram and reported 1.7% of HORA.

Aparna G et al[2] (2014) reported a case of B/L HORA from AA at the lower border of pectoralis minor and a communicating branch from RA reaching the BA in the cubital fossa. In anatomical snuff box RA passes superficial to the tendons.

Shaik Ahammed peera et al [46](2014) dissected 60 UL specimens and observed that RA arose from third part of AA, proximal to the roots of median nerve in 1 UL (1.7%). BA continues as UA in forearm.

Sugna Choudhary[54](2014) reported a case of RA arising from the BA at the level of union of lateral and median roots of median nerve.

Waseem Al Talalwah[66](2015) studied the clinical significance and morphology of RA in 68 upper limbs, observed the HORA in 8.1% of specimens.

Nitin M Mudiraj et al [35](2015) dissected 45 upper limbs , observed that 13.33% of RA arose from BA.

2. COURSE OF RADIAL ARTERY

Prof. Johnston[42] (1921) in his book of synopsis of Regional Anatomy described that RA was comparatively superficial throughout its course except proximally, where it is overlapped by brachioradialis.

Thomas Walmsley[60] (1934) has stated that proximal part of RA is covered by the brachioradialis and its distal part is covered only by skin,superficial and deep fasciae. He also stated that sometimes RA lies superficial to the deep fascia.

George A Piersol[20] **(1930)** has described that the RA descends along the lateral border of forearm upto the level of styloid process of radius, where it turns laterally to reach the dorsum of hand.

J E Frazer[17] (1937) has stated that HORA may be associated with the superficial course of RA passing above the bicipital aponeurosis in CF and superficial to deep fascia in forearm. It may end in the distal part of forearm , its distribution being replaced by the AIA, UA and median artery.

C Latimer Callander, Dean Lewis[8] (1939) has stated that RA in its proximal part is overlapped by brachioradialis and in distal part it lies over the flexor pollicis longus and radius.

Parsons Schaeffer[39] (1942) has stated that RA runs along the radial side of forearm as far as the radial styloid and curves round the lateral border of wrist. Then it enters the palm between the bases of the first and second metacarpal bones.

Barry J Anson[5] (1950) in his book, "An Atlas of Human Anatomy" stated that high division of BA may give rise to smaller or larger RA.

G J Romanes[18](1964) in the book 'Cunninghams textbook of anatomy' has described that extent of the RA is from CF to palm and ends by anastomosing with the UA to form DPA.

Ernest W April[16] in his book described the course of RA as the major vessel which crosses the biceps tendon deep to bicipital aponeurosis , passing superficial to pronator teres muscle and descends along the anterior preaxial border of forearm.

Susan Standring[58] (2008) has stated that from its origin RA runs along the lateral border of forearm accompanied by the venae comitantes. RA lies deep to the deep fascia in the forearm, except in the proximal

part where it is overlapped by the brachioradialis . In the wrist, RA passes dorsal to scaphoid and trapezium deep to tendons of anatomical snuff box where its pulsation is felt.

High origin of RA may sometimes associated with superficial course of RA passing superficial to the deep fascia and tendons of abductor pollicis longus, extensor pollicis longus and extensor pollicis brevis in forearm and anatomical snuff box respectively.

Chandini Gupta et al[9] (2012) in their study of branching pattern of upper limb arteries in 75 cadavers, found that in 1.33% cases RA passes superficial to tendons in anatomical snuff box.

Aparna G et al[2] (2014) reported a case of B/L HORA with RA passing superficial to the tendons of anatomical snuff box.

Prakash et al[40] (2014) dissected 50 UL specimens and observed that in 1 UL specimen, RA passes deep to the tendon of biceps brachii.

Sachs M et al[44](1978) examined RA in 570 soldiers, noted that RA was superficial in the anatomical snuff box in 0.87%.

3. LENGTH OF RADIAL ARTERY

Nasr AY [34](2012) in his study on RA, observed that the mean length of RA was 21. 6cms.

Prakash K G et al[40] (2014) in their study on morphology and clinical importance of RA in 50 cadavers, observed that the mean length of RA, from origin (in CF) to the styloid process was 20.63 cms.

Nitin R Mudiraj et al[35] (2015) in their morphometric study of radial artery in 90 upper limbs, observed that the mean length of radial artery was 21.65cms.

4. BRANCHES OF RADIAL ARTERY

a).RECURRENT RADIAL ARTERY(RRA)

J E Frazer[17] (1937) has stated that RRA is given off from the RA at its commencement.

C Latimer Callander, Dean Lewis[8] (1939) has stated that RRA is given off from the RA near its origin.

G J Romanes[18](1964) in the book 'Cunninghams textbook of anatomy' has stated that RRA may arise from the BA or UA in CF. It may sometimes represented by 2 or more branches from the proximal part of RA.

Priya S patil et al[41] (2004) reported a case of RRA arising from BA in CF associated with HORA.

Susan Standring [58](2008) has stated that RRA arises from RA at the level of elbow and ascends to supply the brachialis, brachioradialis and supinator. It ends by anastomosing with the radial collateral branch of profunda brachii artery. Sometimes it may arise from the BA or UA.

Gupta C et al[21](2012) dissected 75 upper limbs, stated that 12% of RRA arose from BA ,was absent in 1.3% and the rest arose from the radial artery.

Atsumori Hamahata A et al[3] (2012) in their study on usefulness of RRA in transplant of recurrent radial artery based forearm flap, found that RRA arose from RA in 94.4% and from UA in 5.6%.

Shubha et al[51] (2013) in their study on branches and termination of RA in 95 upper limbs, observed RRA as one of the terminal branches of trifurcated BA in 26.6% and in 1% of cases,as one of the terminal branches when BA divides into 5 arteries .

Vazquez T et al[63] (2013) analysed RRA in 332 UL specimens, found that 75% RRA arose from RA, with the presence of accessory recurrent radial artery in 2.7 % of specimens.

Olave et al [36](2014) studied the branches of RA in 50 UL specimens and observed that origin of RRA was from RA in 78%, from BA in 18% and from UA in 4% of specimens.

Prakash et al[40] (2014) in their study stated that RRA arose from the BA, UA and RA in 18%, 4% and 78% of specimens respectively.

b). SUPERFICIAL PALMAR BRANCH(SPB)

George A Piersol [20](1930) has described the SPB of RA as a very slender branch that ends by supplying the thenar muscles.

Thomas Walmsley[60] (1934) has described that SPB arises at the level of root of thumb and runs distally over the thenar muscles or through the substance of thenar muscles to complete the Superficial Palmar Arch (SPA).

C Latimer Callander, Dean Lewis[8] (1939) has stated that SPB is given off from the RA at its distal part. SPB passes through the thenar muscles to meet the UA and completes the SPA.

J Parsons Schaeffer [39](1942) has quoted that SPB courses forwards over the short muscles of thumb to complete the SPA.

Marios Loakas et al[31] (2005) studied the SPA in 200 upper limbs, observed that SPB participates in the formation of SPA in 36% and it ends by supplying the thenar muscles in 35% of specimens.

Suleyman et al [56](2007) studied the variations and clinical significance of SPA in 20 upper limb specimens, reported that 40% of SPB completes the SPA, 35% of SPB ends by supplying the thenar muscles, 20% ends by dividing into APP and ARI and 5% of SPB divide into common digital arteries to the 1st and 2nd web space.

Susan Standring[58] (2008) has stated that SPB of RA arose at the level of wrist. It passes through or over the thenar muscles. It ends by supplying the thenar muscles or anastomoses with the superficial palmar branch of UA to complete the SPA.

Venkata Ramanan Vollala et al[64] (2008) reported a case of rare occurance of "circulus arteriosus pollicis",in which, the SPB of RA communicates with a branch from DPA, at the base of thumb.

Jiji PJ et al[26](2008) stated that SPB was very slender and ends by supplying the thenar muscles.

Mookambica et al[32] (2010) observed a case of SPB of RA which ends by supplying the thenar muscles.

Madhyastha et al [30](2011) studied the morphology of SPA in 75 UL specimens , observed that SPB of RA completes the SPA in 95.74%, SPB courses through the substance of abductor pollicis brevis and divides into 2 common digital arteries to 1st and 2nd web spaces in 2.08% and ends by supplying the thenar muscles in 2.08% of specimens.

Gupta C et al[21] (2012) in their study of RA in 75 UL specimens, found that the SPB of RA was absent in 5.3%, SPB of RA ends by dividing into APP and ARI in 2.7%, it ends by supplying the thenar muscles in 5.5 % and it completes the SPA in 86.5% of specimens.

Vidhya Ramakrishnan et al [65](2014) studied the morphology of SPA in 50 upper limbs, stated that SPB completes the SPA in 86%, it ends by supplying the thenar muscles in 6%, SPB divided into 2 common digital arteries in 6% and SPB divides into APP and ARI in 2% of specimens.

c). ARTERIA PRINCEPS POLLICIS (APP) AND ARTERIA RADIALIS INDICIS (ARI)

Thomas Walmsley [60](1934) has described that APP and ARI are two branches of RA in palm.

George A Piersol [20](1930) has described that APP arise from RA where it enters the palm between two heads of first dorsal interosseous

muscle. Also stated that APP and ARI may arise directly from the deep palmar arch(DPA).

J E Frazer[17] (1937) has stated that APP and ARI arises from the radial extremity of the DPA or from the superficial palmar arch(SPA).

Gellman et al [19](2001) in their study, observed that APP and ARI are the terminal branches of SPB in 11.1%.

Suganthy J et al [53](2002) reported a case of APP and ARI arising from the anterior interosseous artery as common trunk, associated with the absence of RA.

Marios Loakas et al [31](2005) in their study on morphology of arterial arches in 200 upper limbs, stated that APP and ARI arose from the SPA (formed by RA and UA) in 39.5%, from the SPA entirely formed by UA in 31.5%, from the mediano-ulnar SPA in 13.5%, from the radio-medio-ulnar arch in 6.15%.

Suleyman et al[56] (2007) in their study of palmar arches, stated that 40% of APP and ARI arose from the SPA formed by SPB of RA and UA, 35% of these arteries arose from the SPA entirely formed by UA, 20 % 0f APP and ARI arose from the common digital artery to the first web space, branch of SPB and in 5% as the terminal branch of SPB of RA.

Susan Standring [58](2008) has stated that APP arose from the RA at the point where it enters the palm. Also stated that nutrient artery to the first metacarpal arose from the APP and in 20% of cases arterial supply of thumb directly arose from the superficial palmar arch associated with the absence of APP.

Jiji P J et al[26](2008) reported a case of APP and ARI arising from SPA, in which SPA was completed by 1st dorsal metacarpal artery.

Venkata Ramanan Vollala et al [64](2008) reported a case of APP and ARI arising from first common digital artery of SPA.

Sujatha Salgado et al[55](2009) in their study on palmar arches, observed that APP and ARI arose from the SPA(formed by RA and UA) in 55.55%, from the SPA formed entirely by UA(as common digital artery to the 1st web space) in 33.33% and as the terminal division of SPB in 11.17%.

Mookambica et al [32](2010) reported a case of common trunk of origin of APP and ARI from the SPA formed entirely by the UA and they named the trunk as 1st common digital artery.

Madhyastha et al [30](2011) dissected 48 upper limbs, observed that APP and ARI arose as a common trunk from the SPA (formed by UA and RA) in 95.93%, from the SPB which divides into common digital

artery to the 1st and 2nd web space in 2.08 % and from the SPA formed by entirely UA (as the common digital artery to the first space) in 2.08% of specimens.

Gupta C et al[21] (2012) studied the on RA in 75 upper limbs, stated that 2.7% of APP and ARI arose from the SPB of RA as the terminal branches.

Vidhya Ramakrishnan et al[65] (2014) studied the SPA in 50 hands, observed the origin of APP and ARI from SPA (formed by the UA and RA) in 86%, from the SPA entirely formed by UA in 6% , from the 1st common digital artery (branch of SPB) in 6% and from the SPB of RA as the terminal branches in 2% of specimens.

D Srivani[12] (2015) reported a case of APP and ARI arising from the SPA as a common trunk.

d). PALMAR CARPAL BRANCH (PCB)

George A Piersol[20](1930) has stated that PCB is a slender branch and anastomoses with the PCB of UA to form the palmar carpal arch.

G J Romanes[18](1964) in the book 'Cunninghams textbook of anatomy' has stated that the anterior carpal branch of RA passes medially deep to flexor tendons to anastomose with the similar branch of UA to form anterior carpal arch.

Keith L moore[28](1980) has described that palmar carpal branch of RA participates in periarticular arterial anastomosis around the wrist joint.

J E Frazer[17], in the book Buchanan's Manual of Anatomy, has stated that PCB arises from the inner side of RA, at the level of distal border of pronator quadratus.

Susan Standring[58] (2008) has stated that PCB is a slender branch arising from RA near the lower border of pronator quadrates and anastomoses with the recurrent branch of DPA and anterior interosseous artery to form the palmar carpal arch which supplies the structures around the wrist joint.

Gupta C et al[21] (2012) dissected 75 hands and observed the absence of PCB in 26.7% of specimens.

Prakash et al[40] (2014) in their study, stated that PCB arose from RA at the level of wrist.

e).DORSAL CARPAL BRANCH (DCB)

George A Piersol [20](1930) has described DCB as a slender branch of RA which ends by anastomosing with the DCB of UA to form the dorsal carpal arch.

G J Romanes[18](1964) in the book 'Cunninghams textbook of anatomy', has stated that DCB may be replaced by branches of interosseous artery from forearm.

Susan Standring[58] (2008) has stated that DCB arises from the RA deep to the extensor tendons of thumb and runs medially to anastomose with the dorsal carpal branch of UA to form the dorsal carpal arch.

Prakash et al[40] (2014) in their study on RA in 50 UL specimens, observed that DCB arose from RA at the level of wrist joint.

f). FIRST DORSAL METACARPAL ARTERY(FDMA)

G J Romanes[18](1964) in the book 'Cunninghams textbook of anatomy' has stated that FDMA is replaced by perforating branches from the dorsal carpal arch.

Susan Standring[58](2008) has stated that FDMA arises from the RA, before the artery dips between the two heads of first dorsal interosseous muscle. Immediately it divides into two branches to supply the medial and lateral sides of thumb.

Jiji P J et al[26] (2009) in a case report stated that of SPA was completed by FDMA.

Gupta C et al[21] (2012) dissected the branches of RA in 75 upper limbs and stated that FDMA was absent in 9.3% of specimens.

Prakash et al [40](2014) dissected the branching pattern of RA in 50 UL specimens, observed that FDMA arose from RA in the dorsal aspect of hand, in all specimens.

g).ANY OTHER BRANCHES FROM RADIAL ARTERY

Biloid A K et al[6] (2004) reported a case of common interosseous artety(CIA) arising from RA in CF.

Susan Standring[58] (2008) has stated that CIA usually arise from the UA. Sometimes it may arise from the RA.

Abid Angsteen et al[1] (2011) stated in a case report that CIA arose from the RA at the level of elbow.

Sharadhakumar[47] (2013) in their dissection of 200 upper limbs , observed the origin of CIA from RA in 0.5% of specimens.

Baral P et al[4](2002) studied the variations in the arterial pattern of upper limb in 102 upperlimbs, stated that 12.7% of CIA arose from RA in CF.

5. COMPLETION OF SUPERFICIAL PALMAR ARCH(SPA) BY RADIAL ARTERY.

Prof. Johnston [42](1921) in his book of synopsis of Regional Anatomy described that SPA is completed by superficial palmar branch (SPB) of RA.

Thomas Walmsley [60](1934) has stated that SPB of RA completes the SPA.

J E Frazer[17] (1937) has stated that SPA is completed by the SPB of RA. If SPB fails to complete the arch , a branch from APP or ARI may complete the arch.

C Latimer Callander, Dean Lewis[8] (1939) has stated that SPA is completed by the SPB of RA.

J Parsons Schaeffer[39] (1942) has stated that SPB of RA completes the SPA by anastomosing with the UA.

Emanuel B Kaplan[14] (1953) mentioned in his book "Functional and Surgical Anatomy of Hand" that the SPA is formed by anastomosis of SPB of RA with the SPB of UA.

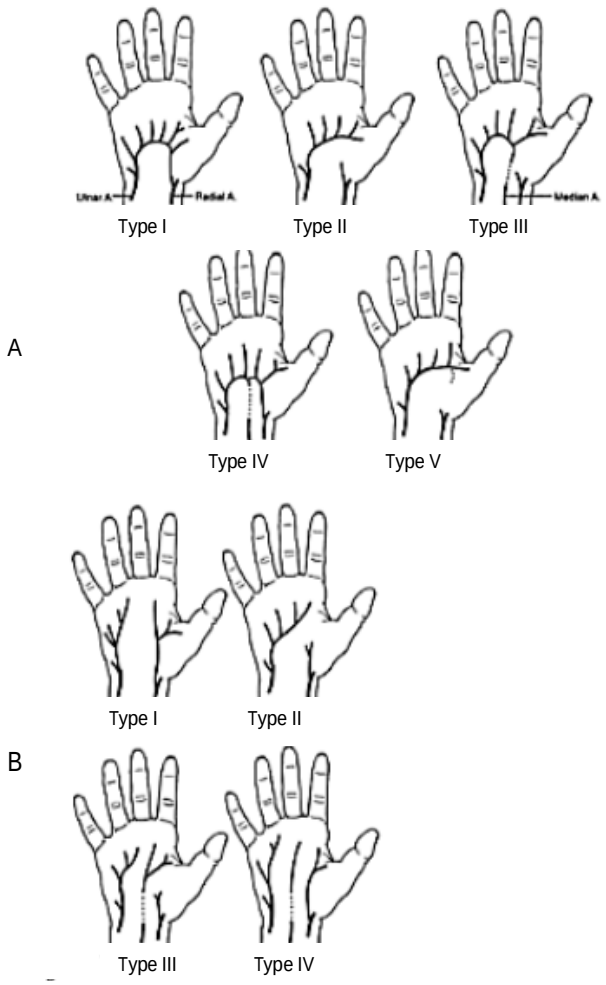
He describes the variations of SPA as follows.

1. First variant 66%, in which SPA was formed completely by the UA.
2. Second variant 30%, in which SPB of RA participates in the formation of SPA.
3. Third variant 4%, in which median artery contributes the formation of SPA

Coleman SS, Anson BJ[10] (1961) studied the arterial pattern of hand in 650 specimens and classified the SPA into **complete** (in which an anastomosis was found between the vessels constituting the arch) and **incomplete SPA** (in which there was an absence of anastomosis between the vessels constituting the arch).

He further sub classified the **Complete arch** into five types:

- Type I: SPA formed by the UA and the SPB of RA-34.5%
- Type II: SPA entirely formed by UA, which contributes the blood supply to thumb and index finger (APP and ARI)- 37%
- Type III: SPA formed by the median and ulnar artery -3.8%
- Type IV: SPA formed by the median, radial and ulnar artery - 1.2%
- Type V: SPA formed by the UA and a communicating branch from the DPA - 2%.



Coleman and Anson's classification of SPA

A: Complete arch B: Incomplete arch

Incomplete arch was further sub classified into four types by him namely

- Type I: SPA formed UA which does not contribute to the blood supply to the thumb and index finger - 13.4%
- Type II: SPA formed by RA which gives rise to common digital arteries to the first two web spaces and UA which gives rise to common digital arteries to the third and fourth web spaces - 3.2%
- Type III: SPA formed by independent radial, median and ulnar artery, where the arteries to the first and second web spaces are from median artery- 3.8%
- Type IV:SPA formed by independent radial, median and ulnar arteries - 1%

This classification of complete and incomplete SPA was universely followed the other authors with regarding to the formation of SPA.

SuganthyJ et al [53](2002) observed a case of absent RA with absent SPA.

Marios Loakas et al[31] (2005) in their study on SPA and DPA in 200 hands, reported 90% complete arch and 10% incomplete arch.Among the complete arches described, it was observed that 36%

belonged to type I,31.5% belonged to type II,13.5% belonged to type III, 6.1% belonged to type IV and 3.5% belonged to type V.

Suleyman et al[56] (2007)in their study, reported 75% complete arch and 25% incomplete arch.

- In complete arch, 40% belonged to type I and 35% belonged to type II.
- In incomplete arch,20% and 5% belonged to type I and type II respectively

Susan Standring[58](2008) has stated that sometimes SPB of RA completes the SPA.

Venkata Ramanan Vollala et al[64] (2008) reported a case of SPA completed by a communicating branch from the DPA.

Jiji P J et al[26](2009) reported a case of SPA completed by FsDMA

Madhyastha et al [30](2011) dissected 45 upper limb specimens, observed the complete arch in 97.91% and incomplete arch in 2.08%.

Among the complete arch described 95.83% was type I and 2.08% was type II and in Incomplete arch 2.08% was type I

Gupta C et al[21] (2012) in their study of RA in 75 UL specimens, stated that SPA was completed by SPB of RA in 86.5% of specimens.

Vidhya Ramakrishnan et al[65] **(2014)** in their study of SPA in 45 upper limbs, stated that SPA was complete in 92% and incomplete SPA in 8% of specimens.

- Among the complete arches described, it was observed that, 86% wae type I and 6% was type II .
- Among the Incomplete SPA described it was observed that,6% was type I and 2% was type II.

6. FORMATION OF DEEP PALMAR ARCH(DPA)

Prof. Johnston[42] **(1921)** in his book of synopsis of Regional Anatomy stated that DPA is the continuation of RA into the palm and the arch is completed medially by the deep branch of UA.

Parsons Schaeffer[39] **(1942)** has stated that RA after entering the palm ends by anastomosing with the deep branch of UA to form the DPA.

Emanuel B Kaplan[14] **(1953)** has mentioned in his book "Functional and Surgical Anatomy of Hand" that anastomosis of RA with the deep palmar branch of UA forms the DPA. Sometimes anterior interosseous artery may participate in the formation of DPA.

Gelleman et al[19] **(2001)** stated that DPA was formed by deep volar branch of RA in 100% of specimens.

Suganthy J et al[53] **(2002)** reported a case of absent RA and the DPA was formed by anterior interosseous artery.

Marios Loakas et al[31] **(2005)** studied the palmar arch in 120 UL specimens, observed that in all limbs, DPA was formed by RA.

Susan Standring[58] **(**2008**)** has stated that anastomosis of the RA with the deep branch of UA forms the DPA at the level of base of metacarpal. Rarely the DPA is incomplete.

Sharadhakumar [47] **(2013)** in his study on palmar arches in 200 specimens, stated DPA was formed by RA in 100% specimens.

Embryology

EMBRYOLOGY

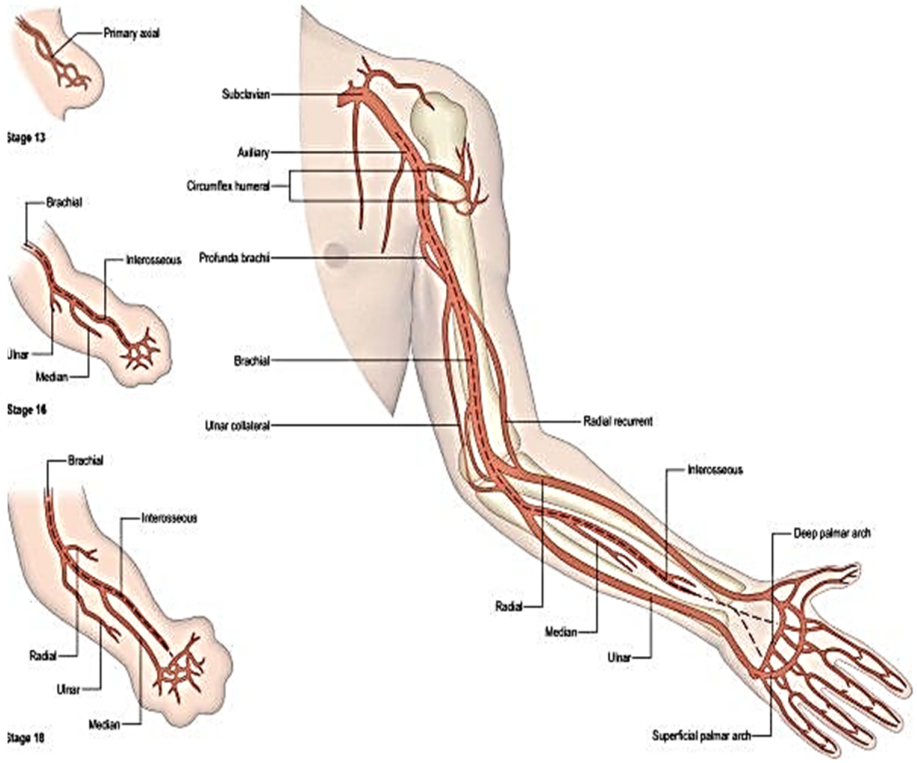
By the end of 4th week, the limb buds develop as outpouchings from the ventrolateral aspect of body wall. From the dorsal aortae, number of small branches arise and reach the developing limb bud to form a primitive capillary plexus. Only one trunk which has the position and relation of the 7th intersegmental artery persists to form the axis artery of upper limb. This trunk later develops into subclavian, axillary, brachial and anterior interosseous artery and terminates in the developing hand as deep palmar plexus.

A branch from the main trunk passes dorsally between the developing radius and ulna as posterior interosseous artery.A second branch accompanies the median nerve upto hand where it ends by forming deep palmar plexus.

Radial and ulnar arteries are the last ones to appear in the forearm. At first, radial artery arises at a higher level than the ulnar artery. Later, radial artery establishes connection with the main trunk at or near the origin of ulnar artery, at which time the proximal part of radial artery disappears. Ulnar artery on reaching the hand links up with the superficial palmar plexus to form the superficial palmar arch. Radial artery passes through the dorsum of hand, but reaches the palmar aspect of hand after traversing the 1st intermetacarpal space and links up with the

deep palmar plexus to form the deep palmar arch. In the dorsum of hand radial artery gives rise to dorsal digital branches[58].

Variations in the branching pattern of arteries may be due to unusual path in the primitive vascular plexus or persistence of vessels that normally disappear or disappearance of vessels that are normally retained[21].



Materials and Methods

MATERIALS AND METHODS

STUDY MATERIALS:

50 adult upper limb specimens

METHOD OF STUDY:

Conventional dissection method

SPECIMEN COLLECTION:

Adult upper limb specimens were obtained from the embalmed cadavers allotted for routine academic dissection to the first year MBBS and BDS students at the Institute of Anatomy, Madras Medical College, Chennai.

CONVENTIONAL DISSECTION METHOD

A horizontal incision was made in arm at the junction of the upper 1/3 and middle 1/3. A vertical incision was made from the middle of cubital fossa to the wrist extending over the palm upto the tip of middle finger. This incision was extended upwards meeting the first horizontal incision. Another horizontal incision was made at the level of wrist and the skin flap was raised medially and laterally. An oblique incision was made on the palm extending from the vertical incision to the thumb.

Another horizontal incision was made in the palm at the level of base of metacarpals and the skin flaps were raised.

The deep fascia of the forearm was divided from the cubital fossa to proximal margin of flexor retinaculum, without damaging the structures deep to the fascia and fascial flap was reflected. The muscles under the fascia are the flexor group medially and the extensor group laterally. The most superficial muscle on the lateral side of the front of forearm is brachioradialis. It was pulled laterally to expose the extensor carpi radialis longus and the extensor and flexor group of muscles were separated. The radial artery lies in the groove between the two group of muscles along with the superficial radial nerve.

Radial artery was traced proximally up to its origin from the brachial artery in the cubital fossa or higher up in the arm.

Then the artery was traced distally , first between the brachioradialis and flexor carpi radialis and then at the distal end of radius between the tendons of these muscles.

The length of radial artery was measured from its origin to the styloid process using thread and the measurement was transferred to the scale.

The branches of the radial artery were noted at its various levels.

At the level of wrist joint, dissection was done to identify the palmar and dorsal carpal arteries and the superficial palmar branch.

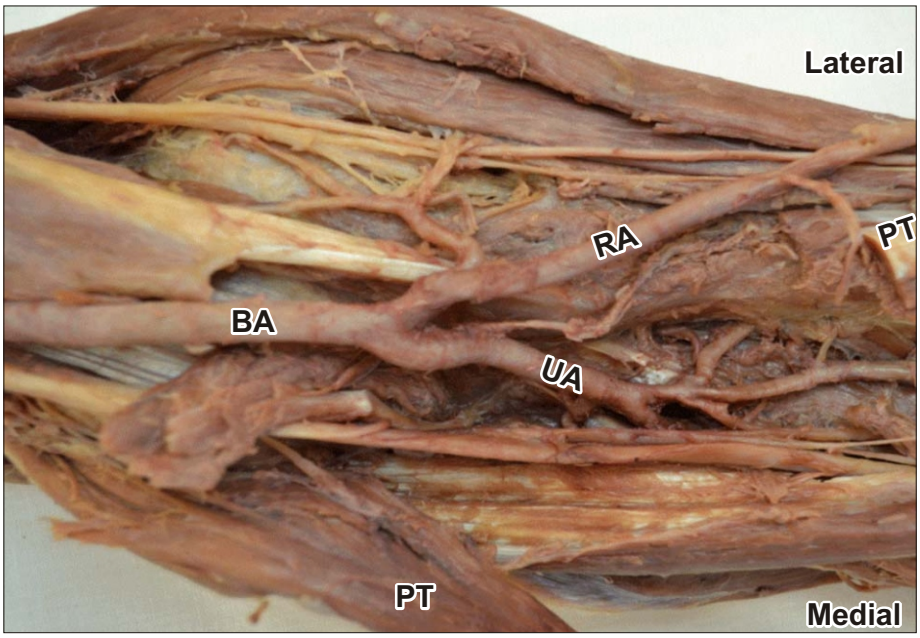
The superficial palmar branch was traced distally into the palm after splitting the palmar aponeurosis. Its contribution to superficial palmar arch was studied.

Further course of the radial artery over the dorsum of hand was dissected and the branches were identified. The radial artery passing between the heads of first dorsal interosseous muscle and its branches, arteria princeps pollicis and arteria radialis indicis in the palm were identified

In the palm, the course of radial artery was traced after cutting the adductor pollicis muscle midway between its origin and insertion. Formation of deep palmar arch was noted.

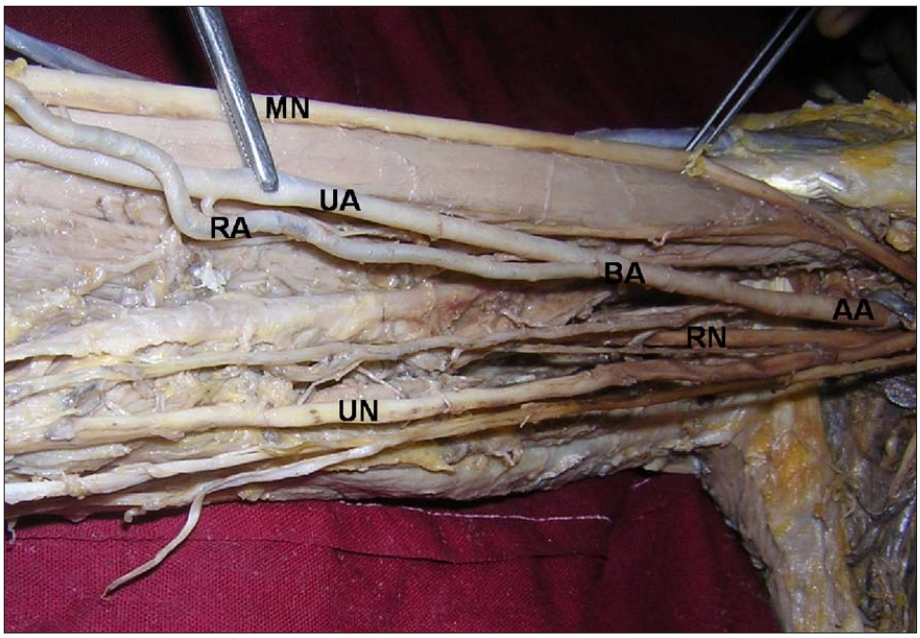
Observation

Figure 1 : Origin of radial artery (RA) from Brachial Artery (BA) in Cubital fossa



PT - Pronator Teres (Cut and Reflected)

Figure 2 : High origin of Radial Artery (RA) from Brachial Artery (BA)



MN - Median Nerve UN - Ulnar Nerve RN - Radial Nerve
AA - Axillary Artery UA - Ulnar Artery

OBSERVATION

1.SITE OF ORIGIN OF RADIAL ARTERY

Of the 50 upper limb specimens dissected, in 47 specimens (94%) the origin of radial artery (RA) was from the brachial artery (BA) in cubital fossa (CF) (Fig :1) In 3 specimens (6%) the RA arose from the BA in the arm.(Fig:2) (Table No:1)

Table No: 1 Site of origin of Radial Artery

Origin of RA	Frequency (n=50)	Percentage(%)
From BA in CF	47	94
From BA in arm(high origin)	3	6

Chart No:1 Site of origin of Radial Artery

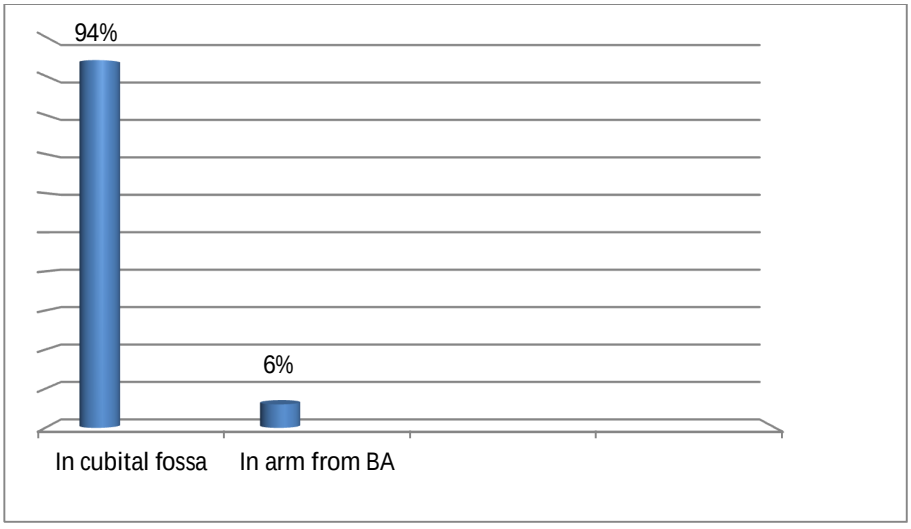
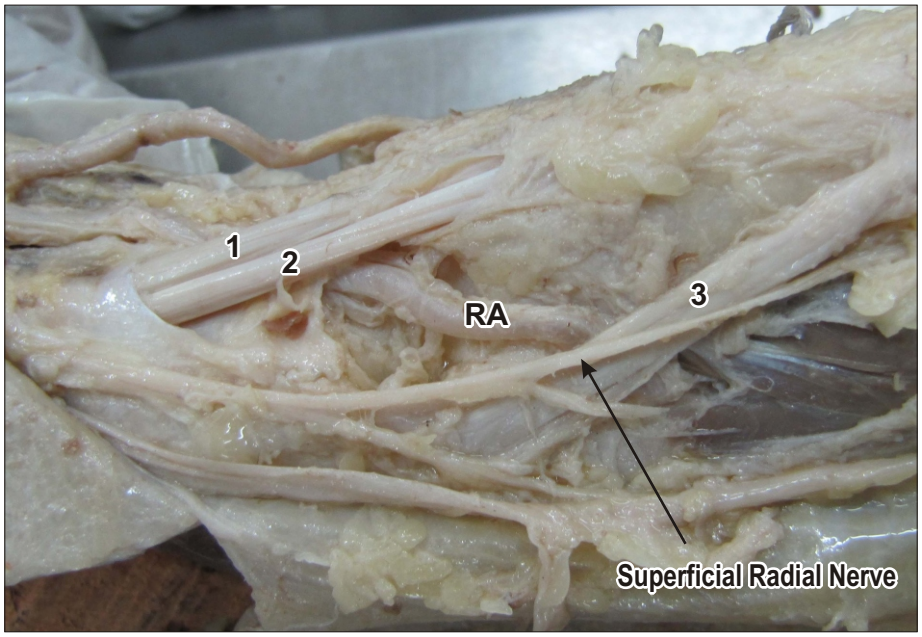
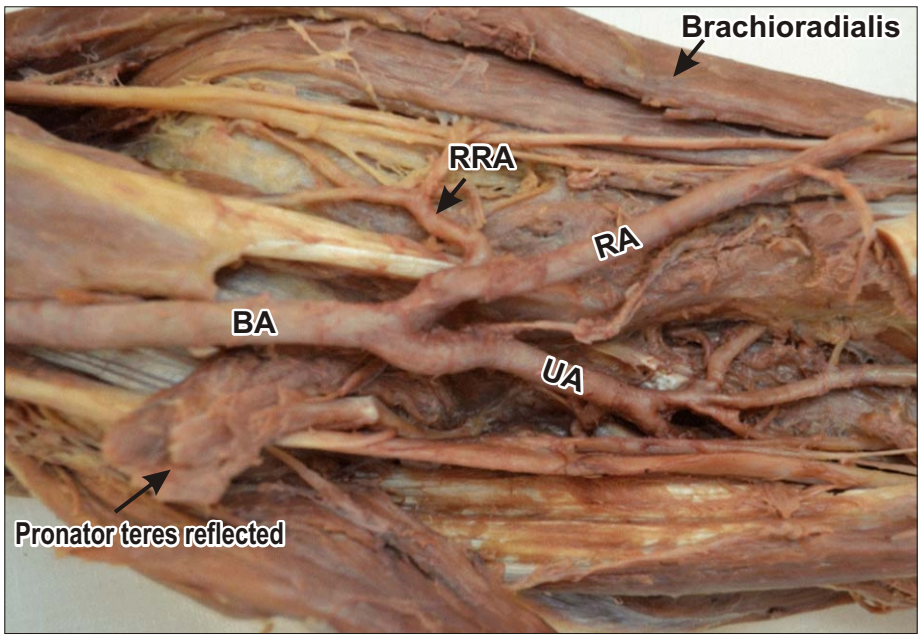


Figure 3 : Radial Artery (RA) in Anatomical Snuff Box



1 - Abductor Pollicis Longus
2 - Extensor Pollicis Brevis
3 - Extensor pollicis Longus

Figure 4 : Origin of Recurrent Radial Artery (RRA) from RA



BA - Brachial Artery UA-Ulnar artery

2. COURSE OF RADIAL ARTERY

In all the dissected specimens, course of the RA was found to be normal. (Fig:3)

3. LENGTH OF RADIAL ARTERY

Length was measured from origin of RA in CF to styloid process, excluding the high origin.

The minimum length of RA was 18cms, maximum length was 23.7cms and the mean length was 21.25cms.(Table No:2)

Table No: 2 length of radial artery

Minimum length	18cms
Maximum length	23.7cms
Mean length	21.25cms

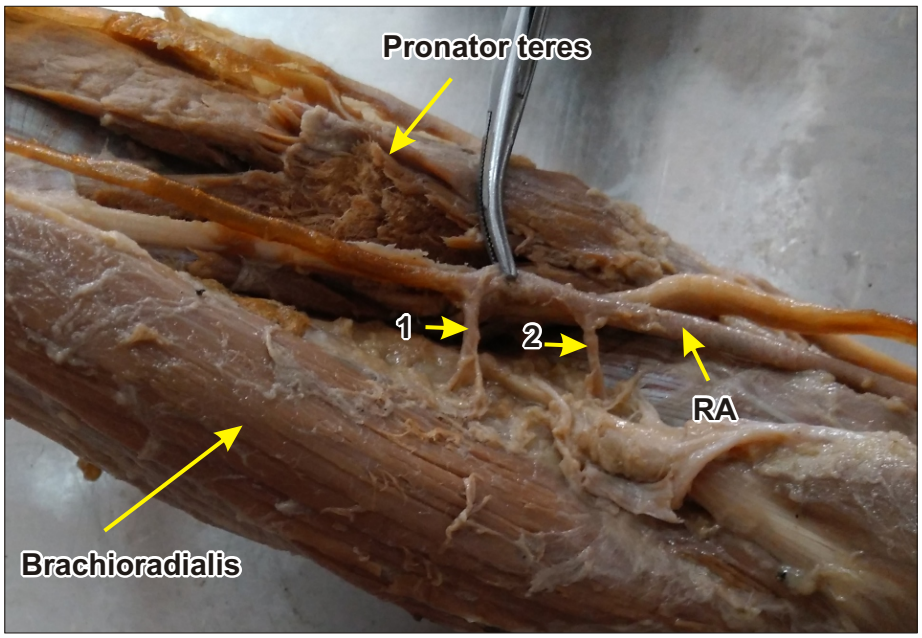
4. BRANCHES OF RADIAL ARTERY

a). RECURRENT RADIAL ARTERY(RRA)

Out of 50 upper limbs dissected, in 48 specimens (96%) RRA arose from the RA near its origin(Fig:4). In 2 specimens (4%) of upper limb RRA arose from the UA(Fig:5).(Table no:3)

Figure 5 : Origin of recurrent radial artery (RRA) from ulnar artery (UA)

Figure 6 : Accessory recurrent radial artery (RRA) from RA

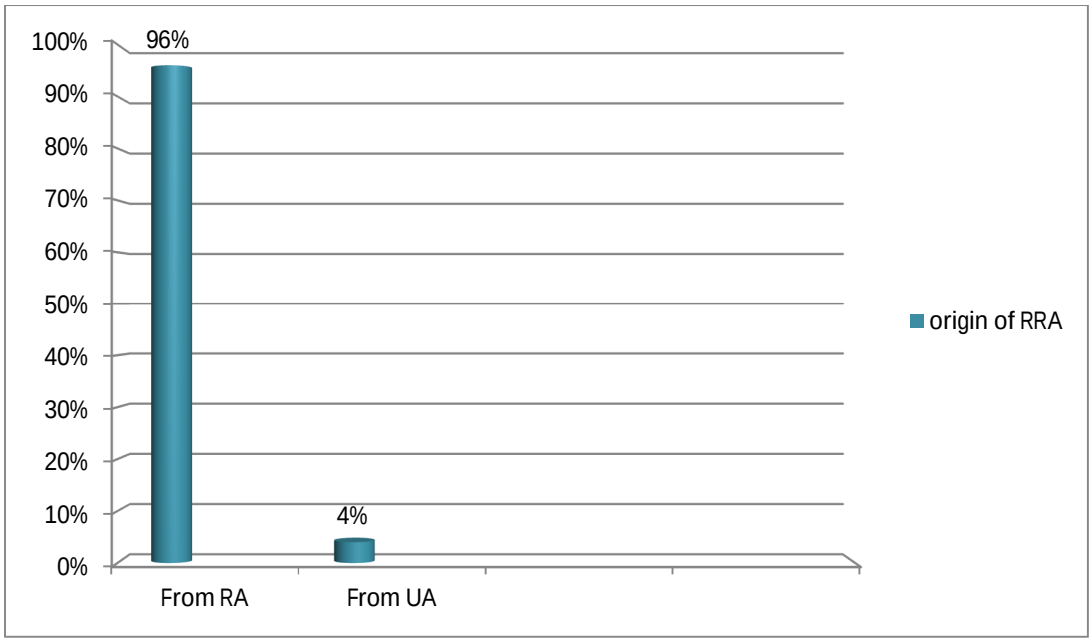


1,2 - Accessory Recurrent Radial Artery

Table No:3 Origin of Recurrent Radial Artery(RRA)

Origin of RRA	Frequency (n=50)	Percentage (%)
From RA	48	96
From UA	2	4

Chart No :2 Origin of recurrent radial artery(RRA)

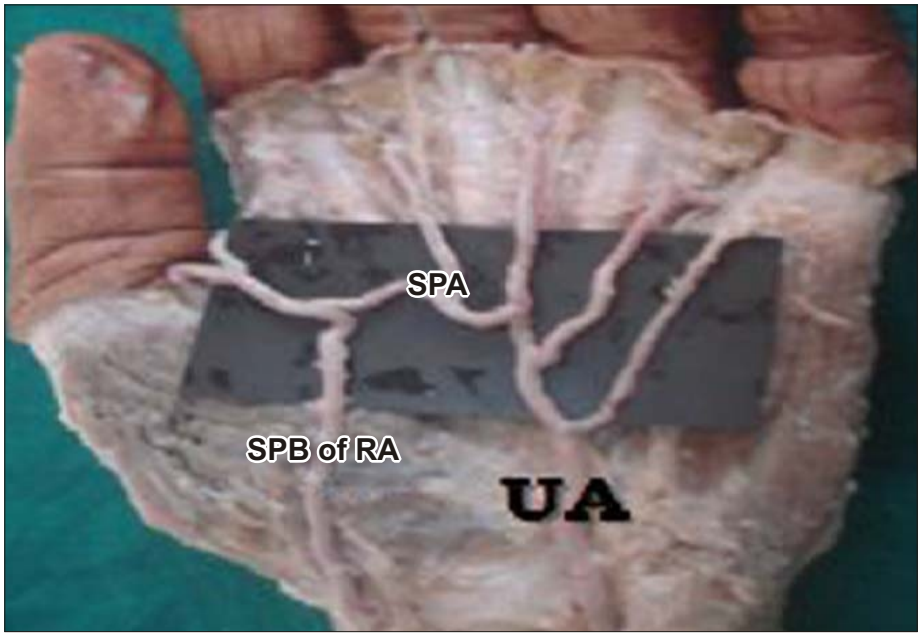


In 2 specimens (4%) accessory RRA was present and they arose from the RA near its origin. (Fig:6)

b). SUPERFICIAL PALMAR BRANCH (SPB)

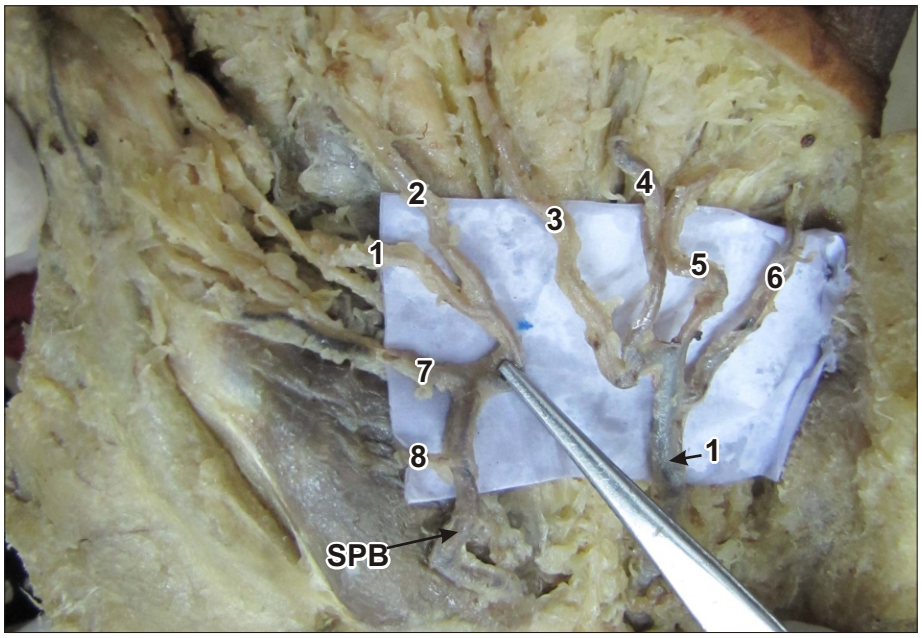
Out of 50 lower limbs dissected, SPB of RA ends by completing the Superficial Palmar Arch (SPA) in 35 (70%) specimens(Fig:7), it ends by dividing into Arteria princeps Pollicis (APP) and Arteria Radialis

Figure 7 : Superficial Palmar Branch (SPB) completes the Superficial Palmar Arch (SPA)



UA - Ulnar Artery RA - Radial Artery

Figure 8 : Superficial Palmar Branch divides into Arteria Radialis Indicis (ARI) & Arteria Princeps Pollicis (APP)



1-ARI, 2-APP, 3, 4, 5 & 6 - Common digital arteries to web space
7 & 8 - Br to Thenar Muscles

Indicis (ARI) in 8 (16%) specimens (Fig:8) and it ends by supplying the thenar muscles in 5 specimens (10%) . It divides into 2 common digital arteries(for the first and second web space) in 2 specimens(4%) (Fig:9). (Table no:4)

Table No : 4 Superficial Palmar Branch (SPB) of RA

SPB of RA	Frequency (n=50)	Percentage (%)
Completing the SPA	35	70
Divides into APP and ARI	8	16
Ends by supplying the thenar muscles	5	10
Divides into common digital arteries to the 1st and 2nd web space	2	4

Chart No :3 Superficial Palmar Branch (SPB) of RA

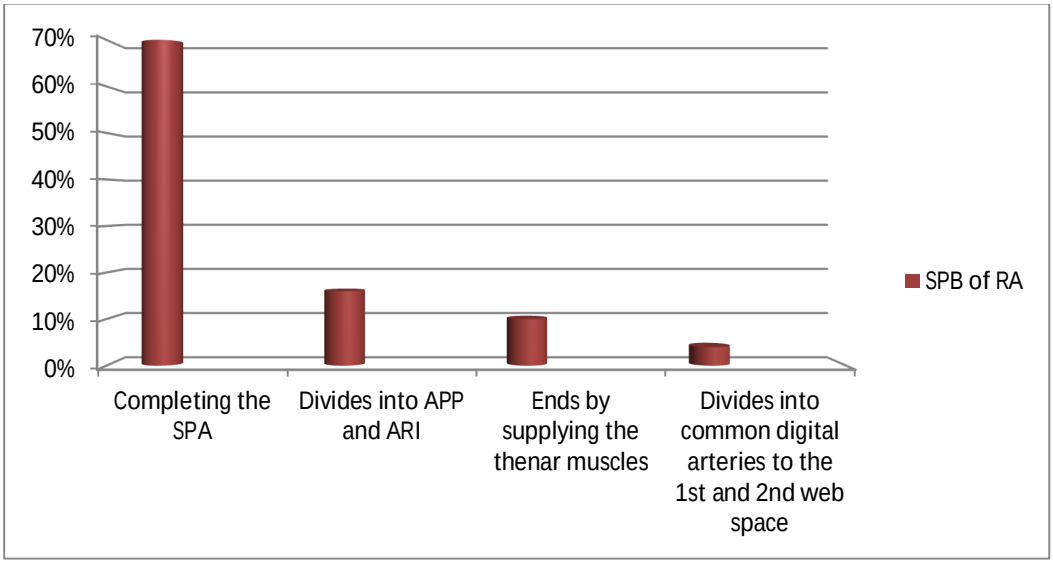
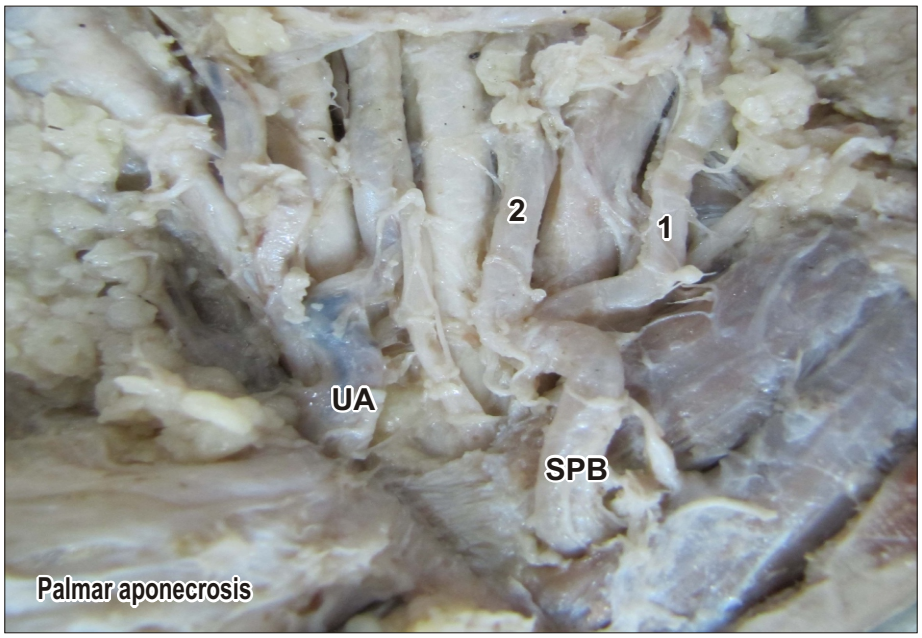
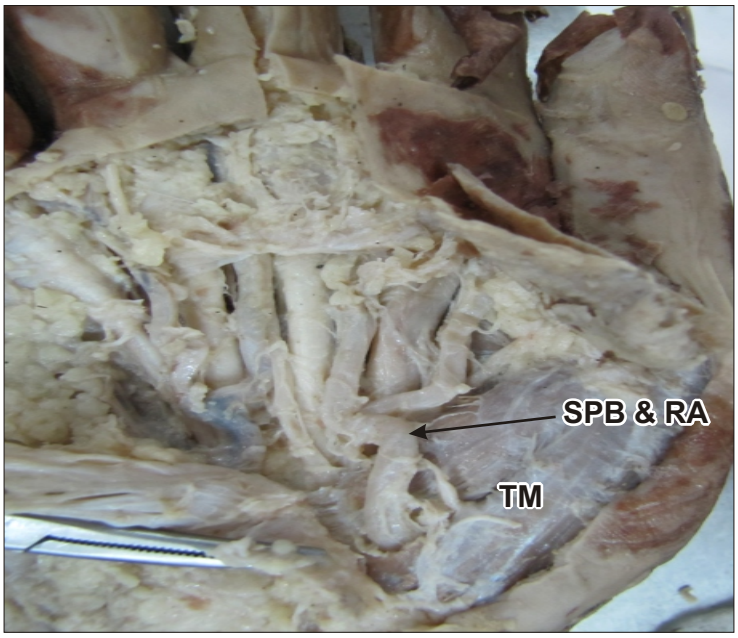


Figure 9 : Superficial Palmar Branch (SPB) divides into arteries to 1st and 2nd web spaces



1 & 2 - common digital arteries to webspaces
UA - Ulnar Artery

Figure 10 : Superficial Palmar Branch (SPB) passes through the Thenar Muscles (TM)



Out of 50 specimens dissected, in 25 specimens (50%) SPB of RA passes through the substance of thenar muscles(Fig:10), in 19 specimens (38%) RA passes superficial to the thenar muscles (Fig:11) and in 6 specimens (12%) it ends by supplying the thenar muscles.(Table no:5)

Table No : 5 Superficial Palmar Branch (SPB) 0f RA

SPB of RA	Frequency (n=50)	Percentage(%)
Passes through the thenar muscles	25	50
Passes superficial to thenar muscles	19	38
Ends by supplying thenar muscles	6	12

Chart No :4 Superficial Palmar Branch (SPB) of RA

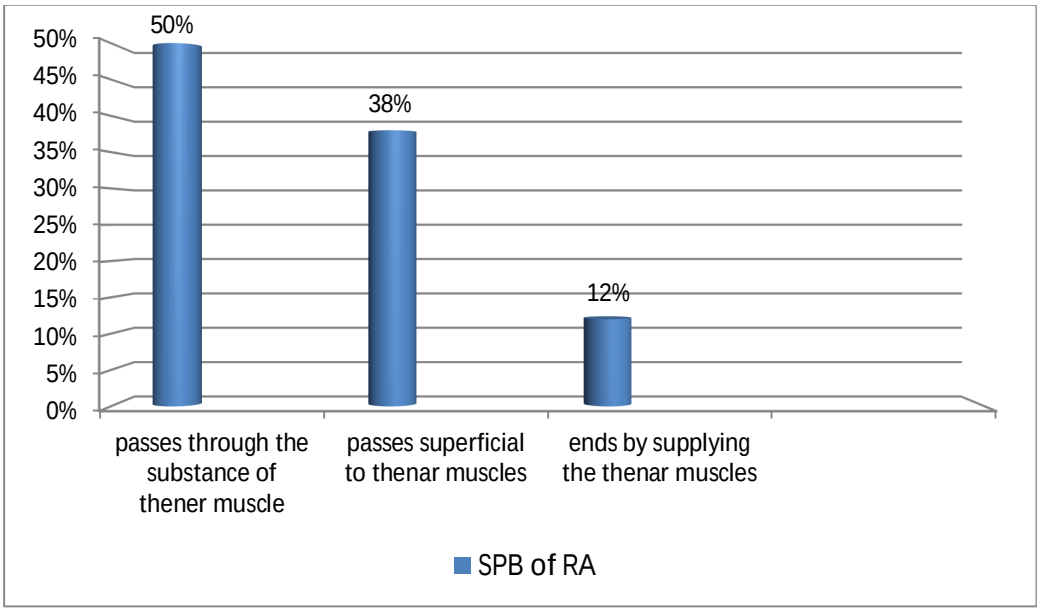
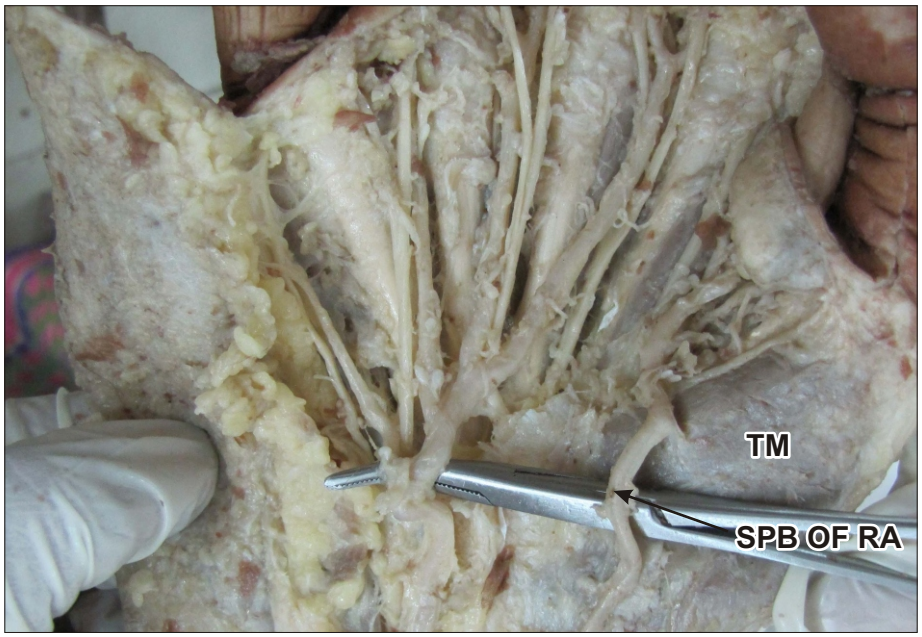
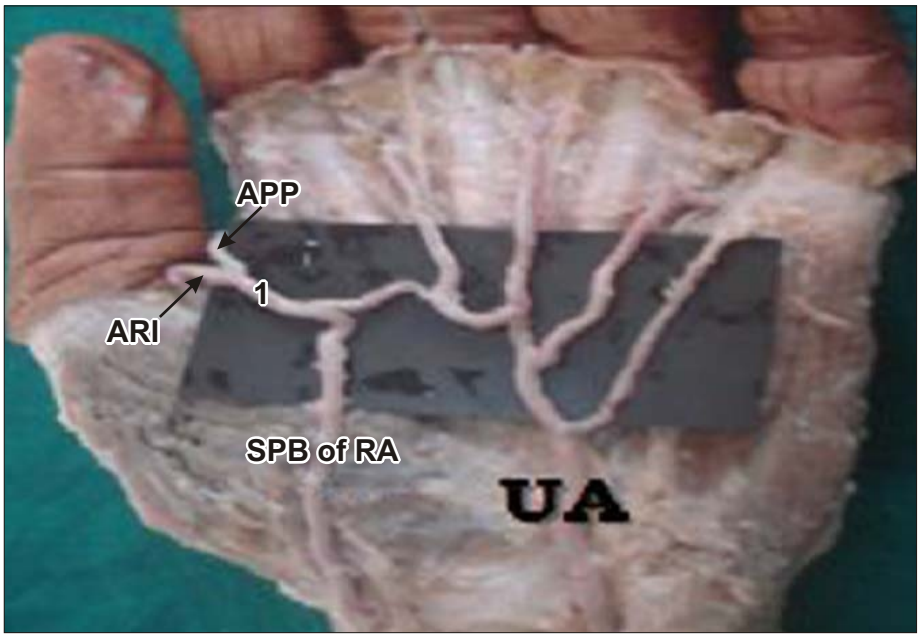


Figure 11 : Superficial Palmar Branch (SPB) passes over the Thenar Muscles (TM)



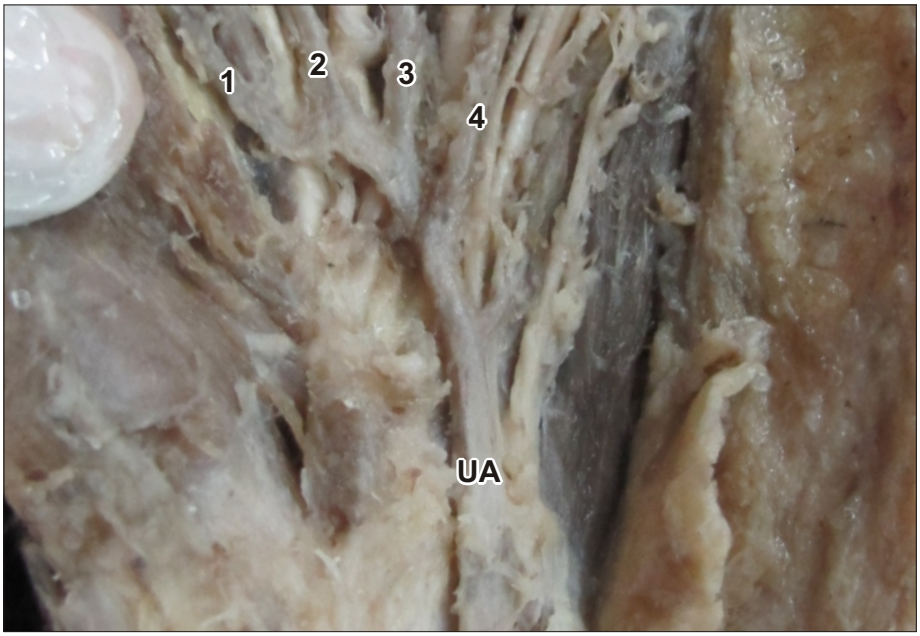
RA - Radial Artery

Figure 12 : Arteria Radialis Indicis (ARI) & Arteria Princeps Pollicis (APP) from Complete Superficial Palmar Arch Type-I



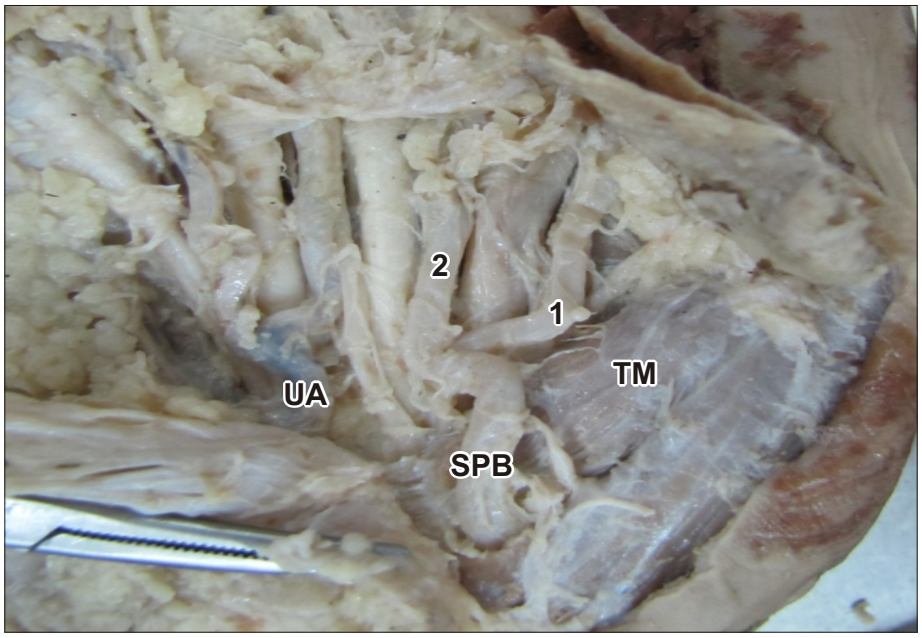
1 - Common digital arteries to first webspaces
SPB - Superficial Palmar Branch RA-Radial Artery UA-Ulnar Artery

Figure 13 : Origin of APP and ARI from superficial palmar arch Type-II



1, 2, 3 & 4 - common digital arteries to web space

Figure 14 : Origin of APP and ARI from artery to 1st web space



1,2 - Common digital artery to the 1st and 2nd Web Space
TM - Thenar Muscles

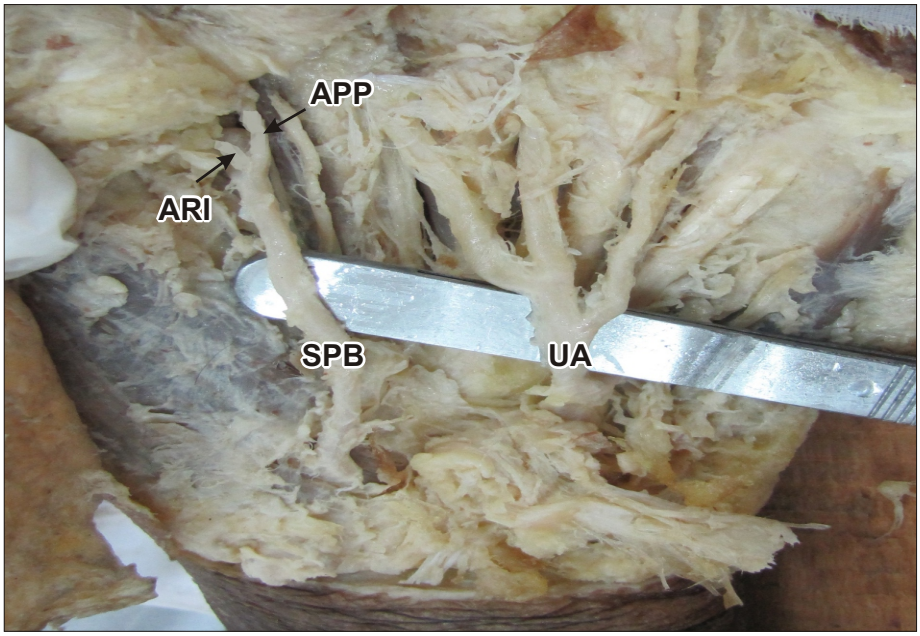
c). ARTERIA PRINCEPS POLLICIS (APP) AND ARTERIA RADIALIS INDICIS(ARI)

Out of 50 specimens dissected, APP and ARI arose as common trunk from Superficial Palmar Arch(SPA) (formed by the SPB of UA and RA) in 36 specimens (72%) (Fig:12), from the SPA formed by the UA alone in 4 specimens (8%) (Fig:13), from the common digital artery (branch from the SPB) to the first web space in 2 specimens (4%) (Fig:14) and as the terminal branches of SPB in 8 specimens (16%) (Fig:15). (Table no:6)

Table No : 6 Origin of APP and ARI

Origin of APP and ARI	Number of specimens (n=50)	Percentage (%)
From SPA (formed by the of UA and RA)	36	72
From SPA formed by the UA alone	4	8
From common digital artery to the first web space(from SPB)	2	4
As the terminal branches of SPB	8	16

Figure 15 : APP and ARI are terminal branches of superficial palmar branch (SPB)



ARI - Arteria radialis indicis APP - Arteria Princeps Pollicis
UA - Ulnar Artery

Figure 16 : Palmar Carpal Branch (PCB) of Radial Artery (RA)

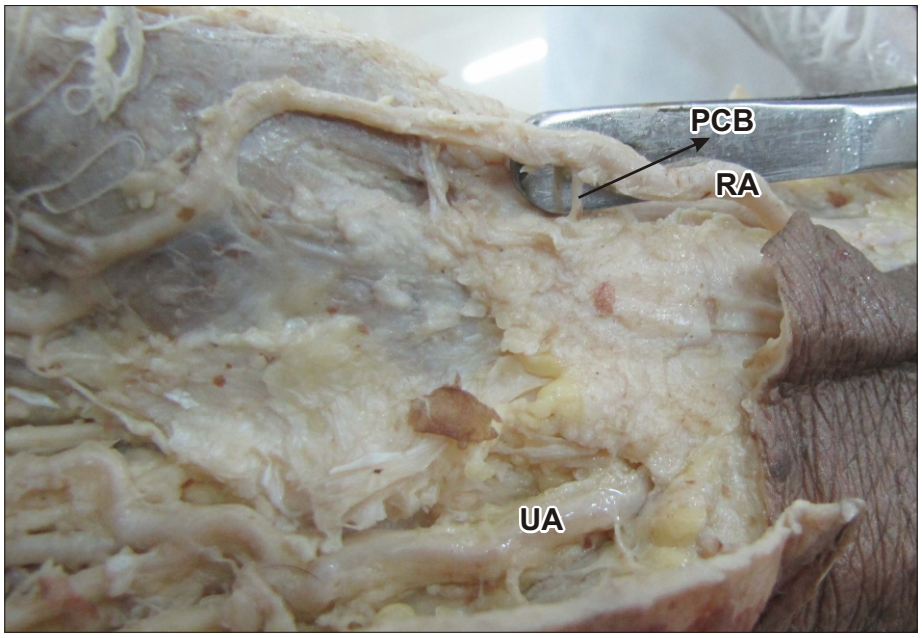
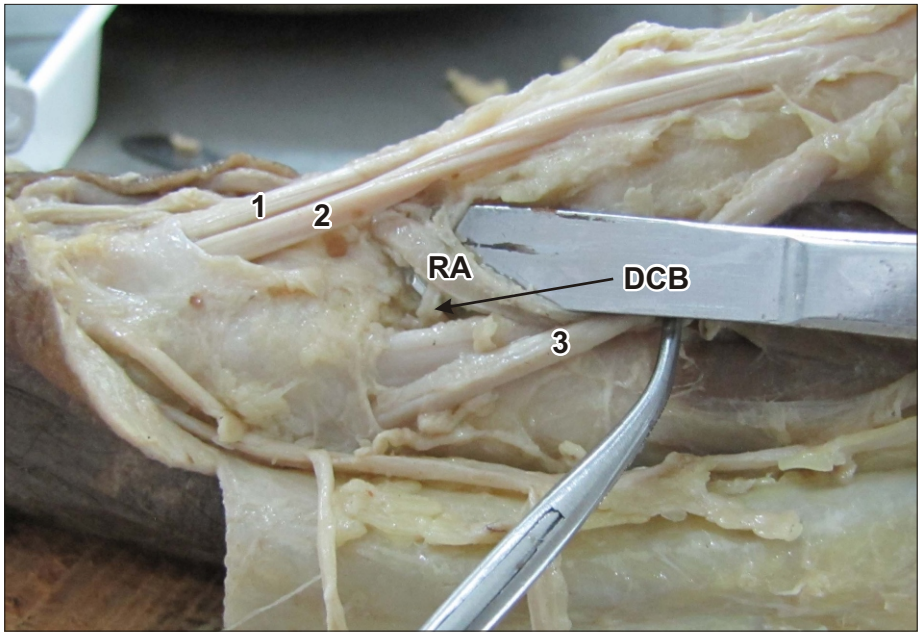
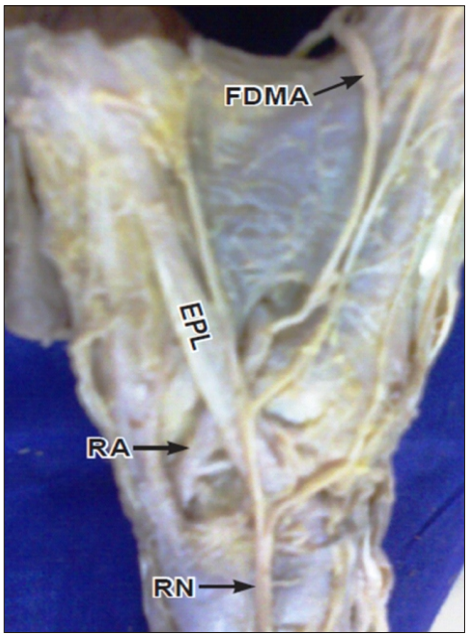


Figure 17 : Dorsal Carpal Branch (DCB) of Radial Artery (RA)



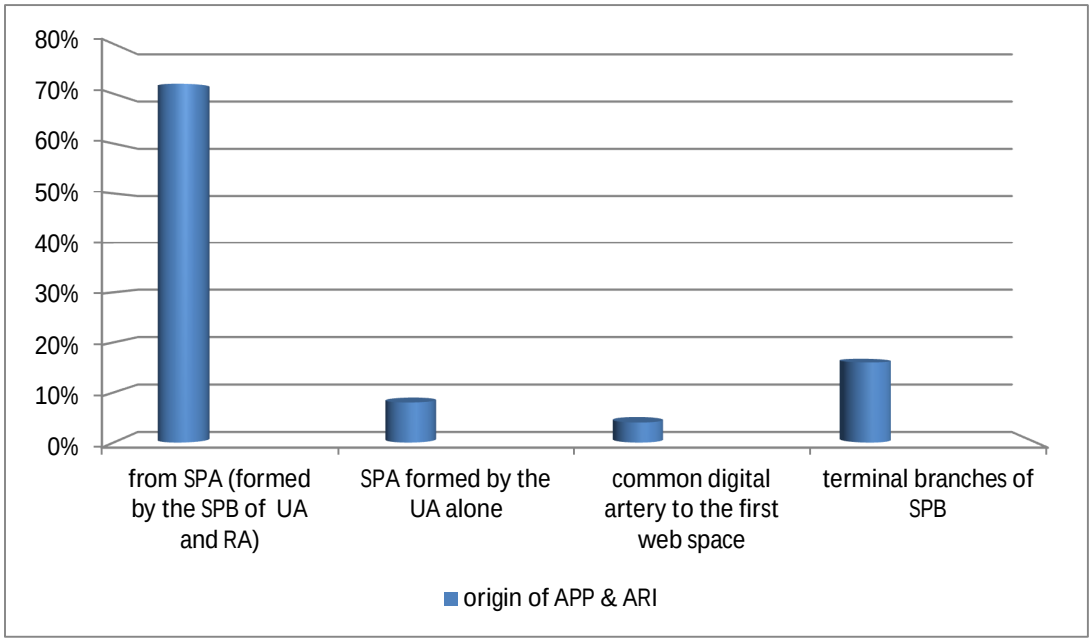
1, 2 & 3 - Tendons of anatomical snuff box

Figure 18 : Origin of First Dorsal Metacarpal Artery (FDMA)



RA - Radial Artery, EPL - Extensor Pollicis Longus
RN - Radial Nerve

Chart No :5 Origin of APP and ARI



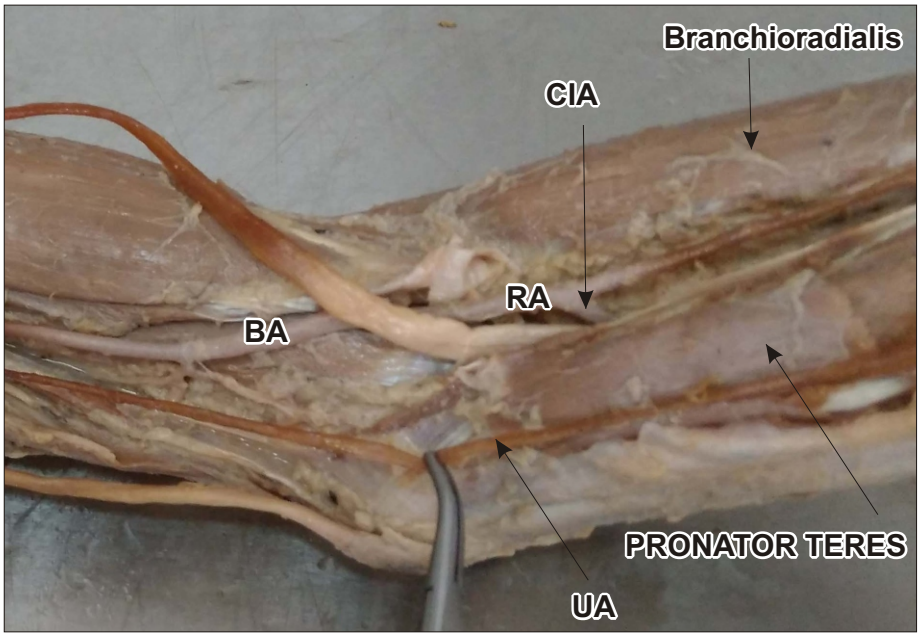
d). PALMAR CARPAL BRANCH (PCB)

In all the dissected specimens, PCB of RA arose from the RA at the level of wrist joint (Fig:16).

e).DORSAL CARPAL BRANCH (PCB)

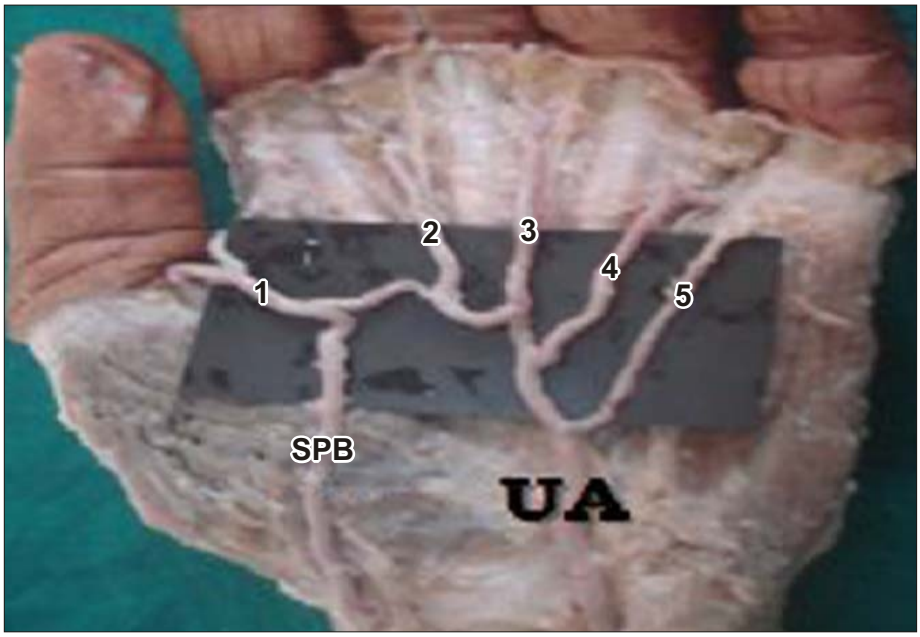
DCB of RA arose from the RA at the level of wrist joint in all the 50 dissected specimens .(Fig:17).

Figure 19 : Common Interosseous Artery (CIA) from Radial Artery (RA)



UA - Ulnar Artery BA - Brachial Artery
PT - Pronator Teres (Cut and Reflected)

Figure 20 : Superficial palmar arch complete type-I



1, 2, 3 & 4 - common digital artery to webspaces from superficial palmar arch.
5 - proper digital artery to medial side of little finger
SPB - Superficial Palmar Branch UA - Ulnar Artery

f).FIRST DORSAL METACARPAL ARTERY(FDMA)

In all the dissected specimens, FDMA arose from the RA in the dorsal aspect of hand before it passes between the two heads of first dorsal interosseous muscle (Fig:18).

g).ANY OTHER BRANCHES OF RA

Out of 50 upper limb specimens dissected, Common Interosseous Artery (CIA) arose from the RA in CF in 1 specimen (2%). In 49 specimens (98%) CIA arose from the UA (Fig:19).(Table no:6)

Table No : 6 Origin of CIA

Origin of CIA	Frequency (n=50)	Percentage
From UA	49	98%
From RA	1	2%

Chart No :6 Origin of CIA

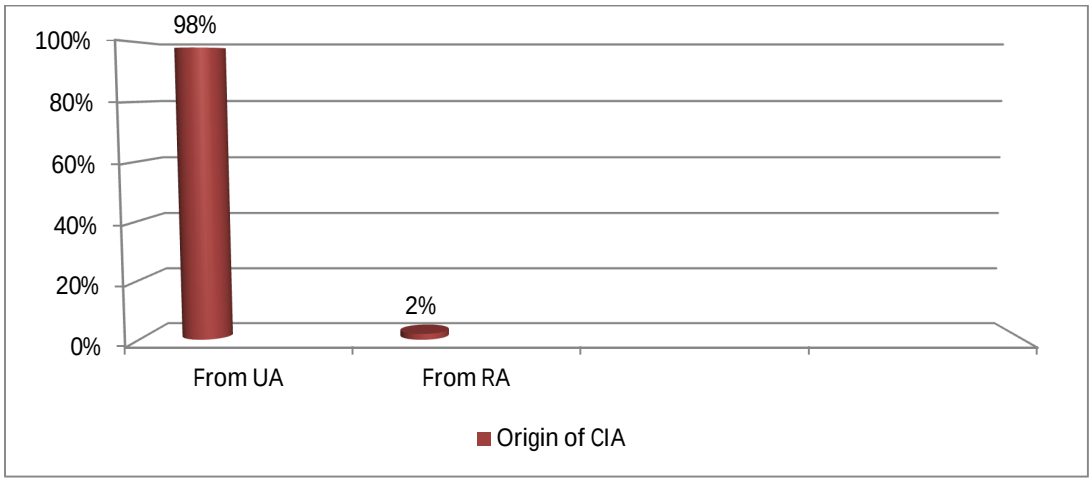
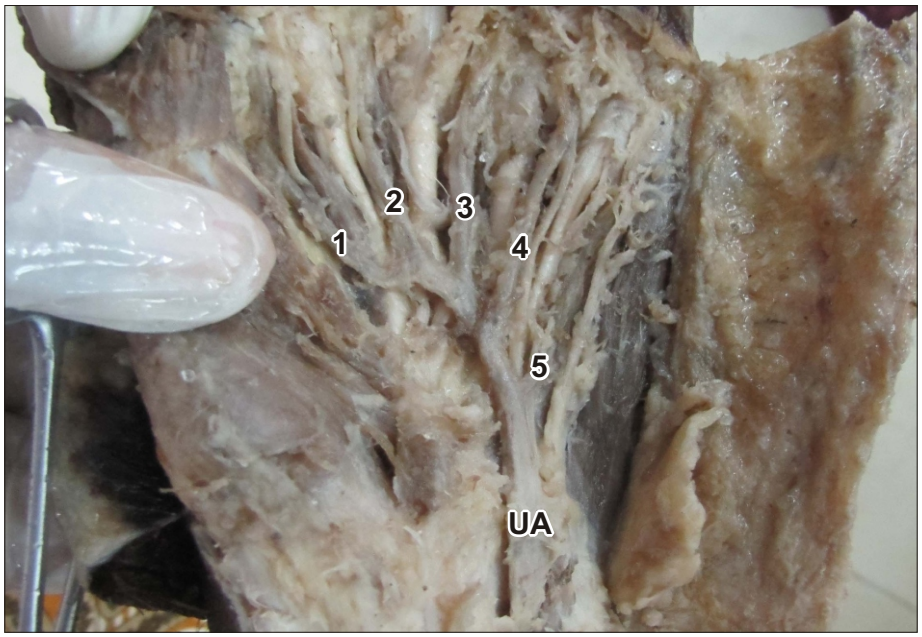
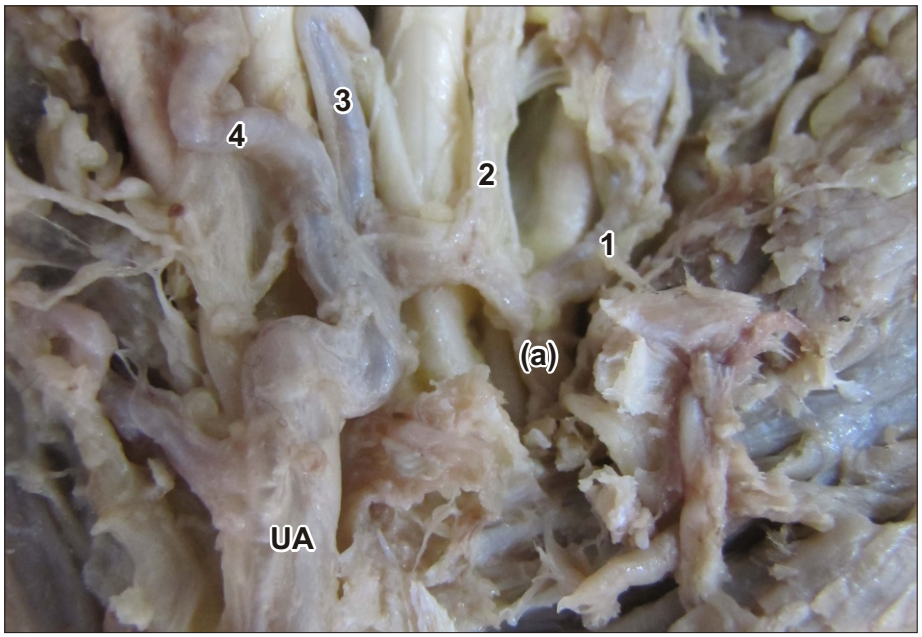


Figure 21 : Superficial palmar arch complete Type-II



1, 2, 3 & 4 - common digital artery to webspaces.
5 - proper digital artery to medial side of little finger
UA - Ulnar Artery

Figure 22 : Superficial palmar arch complete type-V



(a) Communicating branch deep palmar arch
1, 2, 3 & 4 - Common digital artery to web spaces
UA - Ulnar Artery

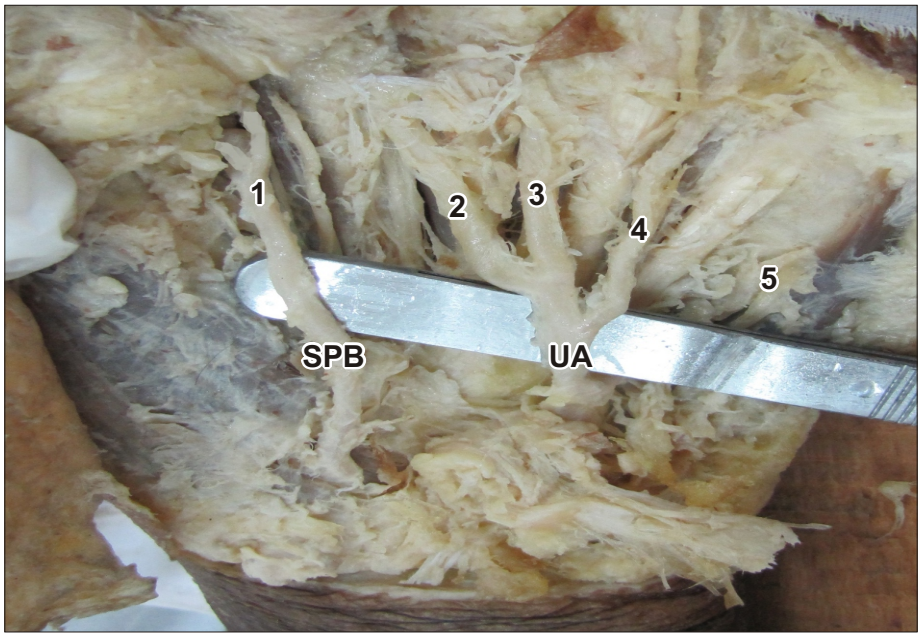
5.COMPLETION OF SUPERFICIAL PALMAR ARCH (SPA) BY RADIAL ARTERY

Out of 50 specimens, complete arch was observed in 40 specimens (80%) and incomplete arch was observed in 10 specimens (20%.) **(**Table No: 7)

The complete SPA was classified in to five types based on the classification of Coleman and Anson as follows:

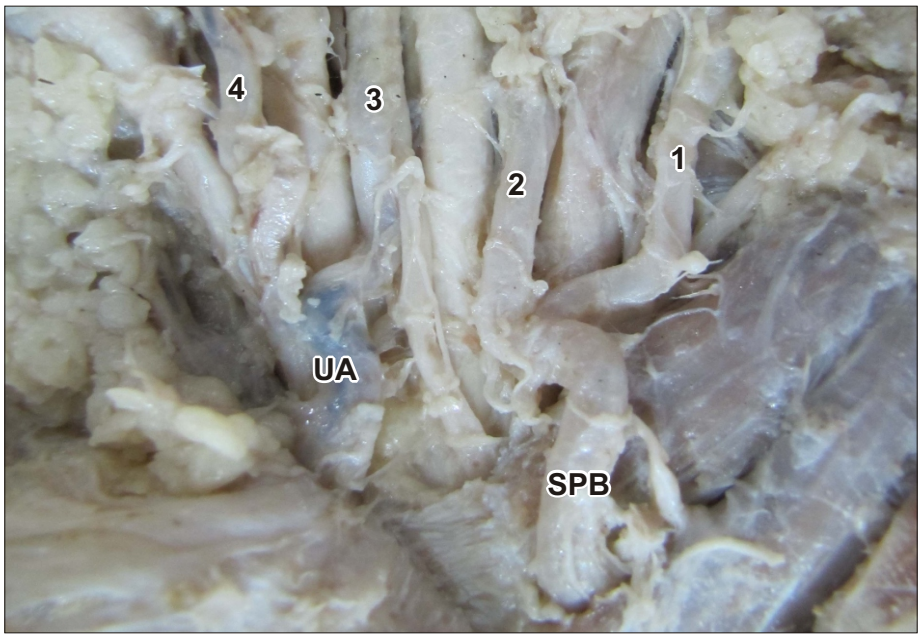
- Type I: SPB of RA UA with the SPB of RA, observed in 35 specimens (70%)(Fig:20).
- Type II: Entirely formed by the UA, observed in 4 specimens (8%)(Fig:21).
- Type III: mediano ulnar arch, not observed in the present study
- Type IV: radio- mediano- ulnar arch, not observed in the present study
- Type V: UA with the branch from deep palmar artery, observed in 1 specimen (2%) (Fig:22).

Figure 23 : Superficial palmar arch incomplete type-I



1, 2, 3 & 4 - common digital artery to webspaces.
5 - proper digital artery to medial side of little finger
SPB - Superficial palmar branch UA-Ulnar Artery

Figure 24 : Superficial palmar arch incomplete Type-II



1 & 2 - common digital artery to web spaces from SPB
3 & 4 - common digital artery to web spaces from UA
UA - Ulnar artery SPB - Superficial Palmar Branch

The incomplete SPA was classified into four types based on the classification of Coleman and Anson as follows:

- Type I: SPA formed by the UA, which does not contribute to the blood supply of thumb and index finger (APP and ARI) , which arose from the SPB of RA, observed in 2 specimens (4%) (Fig:23).

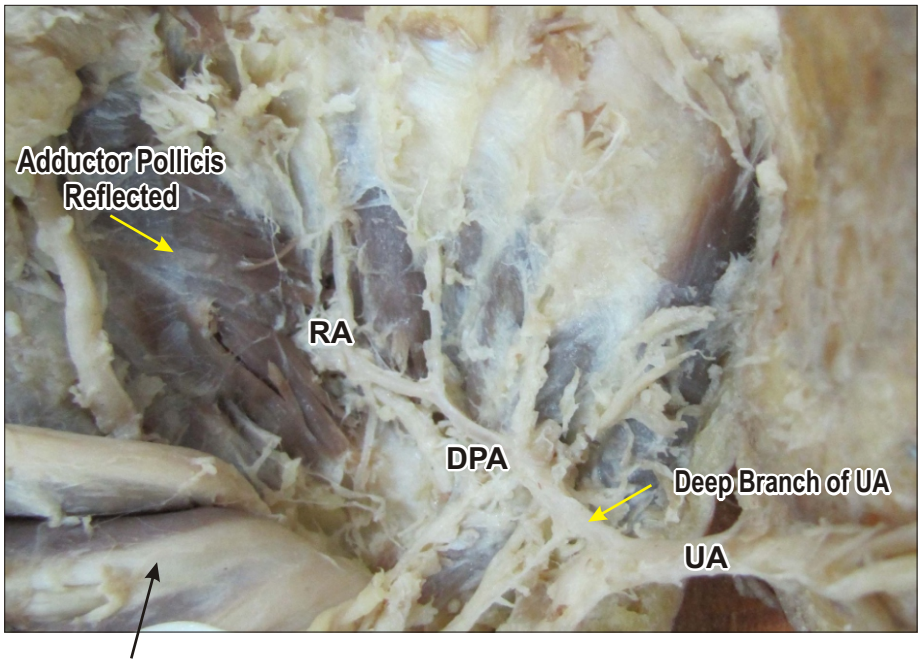
- Type II: common digital artery to the 1st and 2nd web spaces was from the SPB of RA and to the 3rd and the 4th web spaces was from the UA, observed in 8 specimens (16%) (Fig:24).

- Type III: SPA formed by the independent radial, median and ulnar arteries with APP and ARI as branches from the median artery, not observed in the present study

- Type IV: SPA formed by the independent radial, median, ulnar arteries. Common digital artery to the 1st web space from RA, artery to 2nd web space from median artery and arteries to the 3rd and 4th web space from UA, not observed in the present study

Median artery was not observed in this study.

Figure 25 : Deep Palmar Arch (DPA)



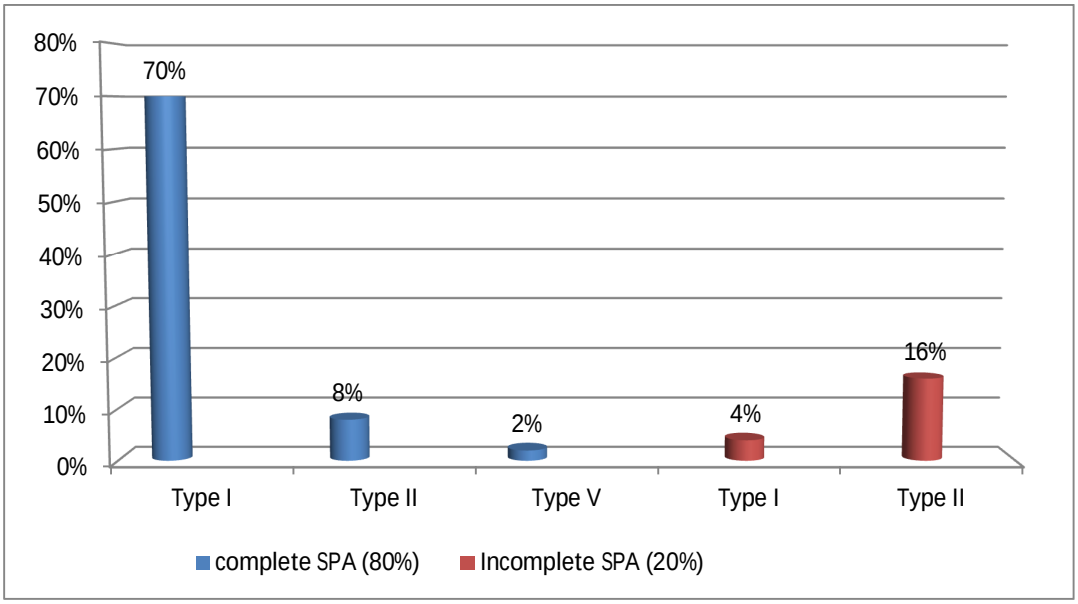
Flexor Digitorum profundus cut and reflected

RA - Radial Artery, UA - Ulnar Artery

Table No:7 Completion of Superficial Palmar Arch (SPB) by Radial Artery

SPA		No of specimens (n=50)	Percentage (%)	Total (%)
Complete SPA	Type I	35	70	80
	Type II	4	8	
	Type V	1	2	
Incomplete SPA	Type I	2	4	20
	Type II	8	16	

Chart No :7 Completion of Superficial Palmar Arch (SPB) by Radial Artery



6. FORMATION OF DEEP PALMAR ARCH (DPA)

In all the dissected specimens, DPA was formed by the RA, completed by the deep palmar branch of UA (Fig:25).

Discussion

DISCUSSION

1.ORIGIN OF RADIAL ARTERY(RA)

G J Romanes[18] (1972) in his book, Cunninghams textbook of anatomy has stated that RA may absent and its territory being supplied by other arteries in forearm.

Suganthy J et al[53] (2002) reported a case of absence of RA in the right upper limb.

Omer Faruk Dogan et al[37] (2004) observed that the absence of RA was in 8.33% of patients who underwent CABG, associated with persistence of median artery.

Susan Standring[58] (2008) in the book ‘‘Gray’s Anatomy’’ has stated that Radial artery (RA) arises from the (Brachial Artery) BA in (Cubital Fossa) CF 1cm below the elbow crease.

Chandini gupta et al [9](2012) stated that 94.8 % of RA arose from the BA in CF.

Nasr AY[43] (2012) reported that the origin of RA was from BA in the CF in 84% of specimens.

Sharadhakumar[47] (2013) observed the origin of RA from BA at the level of neck of radius in 86% of specimens.

Prakash et al[40] (2014) stated that, RA arose from the BA in CF in all the specimens (100%).

Nitin R Mudiraj et al[35] (2015) said that 86.6% of RA arose from the BA in CF.

In the present study, 96% of RA arose from the BA in CF similar to the studies mentioned above(Table no:8). The absence of RA as mentioned in suganthy J et al and Omer Faruk Dogan et al was not found in the present study. The persistence of median artery was also not found in this study as noted by Omer Faruk Dogan et al.

Table No : 8 Origin of RA from BA in CF

Name of the Study	Origin of RA from BA in CF
Chandini gupta et al (2012)	94.8%
Nasr A Y (2012)	84%
Sharadhakumar (2013)	86%
Prakash et al (2014)	100%
Nitin R Mudiraj et al (2015)	86.6%
Present study	**96%**

HIGH ORIGIN OF RADIAL ARTERY (HORA)

W Henry Hollinshead[23] (1969) has stated that HORA was seen in 14.27%, in which 2.13% of RA arose from the AA and 12.14% of RA arose from the BA in arm.

Ernest W April in his book stated that RA arose from the BA anywhere in arm in 14% of specimens.

Baral P et al[4] (2002) observed the origin of RA from BA in arm in 4.9% of specimens.

Priya S patil et al[41] (2004) reported a case of origin of RA from first part of AA.

Ileana Dinea et al[24] (2010) stated that HORA was observed in 7.14% of specimens.

Chandini gupta et al [9](2012) in their study, observed that 2.66% of RA arose from AA and 2.66% of RA arose from BA in arm.

Nasr A Y [34] (2012) stated that HORA was found in 16% of specimens in their study.

Shiny et al[49] (2013) reported a case of HORA from AA, proximal to the union of medial and lateral roots of median nerve.

Sharadhakumar[47] (2013) in their study observed HORA from BA in arm in 13% of specimens.

Shubha et al[51] (2013) stated that origin of RA in arm from BA in 10.1% of specimens.

Li L et al[29] (2013) reported that HORA in 1.7% of patients who underwent transradial coronary angiogram.

Padma Varlekar et al[38](2013) stated that 3.12% of RA arose from the BA in arm.

Shaik Ahammed peera et al[46] (2014) observed the origin of RA from AA at the level of formation of median nerve in 1.7% of specimens.

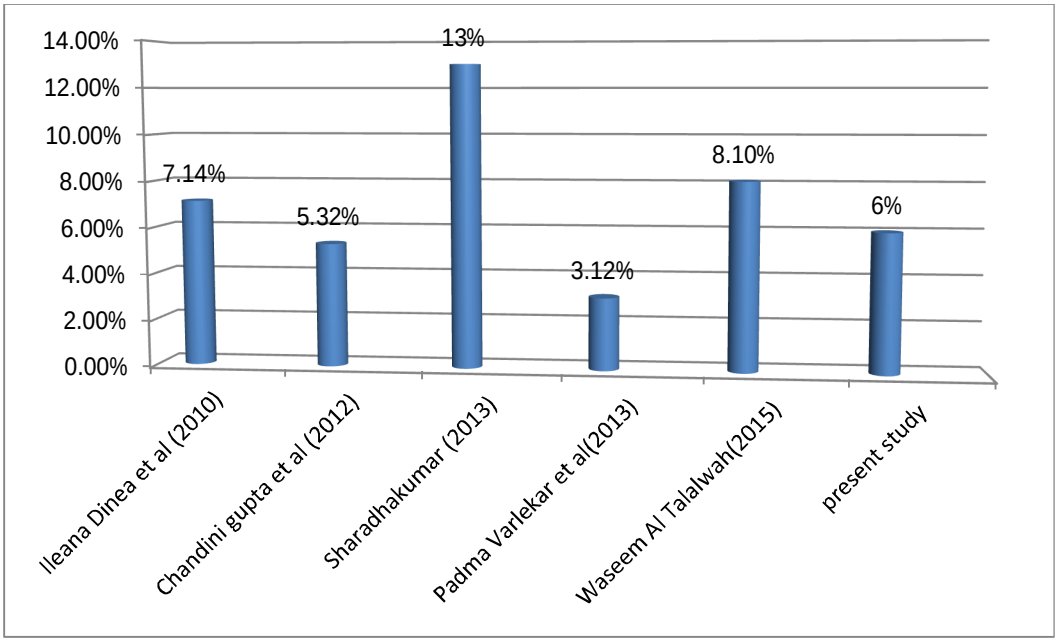
Waseem Al Talalwah[66] (2015) stated the HORA from BA in arm in 8.1% of specimens.

In the present study HORA from BA in arm was observed in 3 specimens (6%).(Table no:9)

Table No : 9 High origin of RA(HORA)

Name of the Studies	Percentage
Baral P et al(2002)	4.9%
Ileana Dinea et al (2010)	7.14%
Chandini gupta et al (2012)	5.32%
Sharadhakumar (2013)	13%
Padma Varlekar et al (2013)	3.12%
Waseem Al Talalwah (2015)	8.1%
Present study	**6%**

Chart:8 High origin of RA(HORA)



Radial artery was the third most common artery used as a graft for CABG, as the diameter of RA is similar to that of coronary artery. RA arising at a higher level may have a smaller diameter which cannot be used for grafting and also leads to failure of catheterisation[11].

Autologous grafting of RA has a decreased incidence of hypoperfusion syndrome compaired to the internal mammary artery grafting[45]. High origin of RA in the arm is more prone to accidental injury and heavy bleeding[62]. It can be mistaken for vein and ligated during surgery on humerus leading to gangrene of hand.

Usually the blood pressure is recorded by auscultating the BA in the CF. HORA may be associated with difficulty in measuring the blood pressure.

Hence knowing the origin of RA is mandatory for the orthopaedic surgeries and vascular surgeries.

2.COURSE OF RADIAL ARTERY

Thomas Walmsley[60] (1934) in his book, stated that proximal part of RA was overlapped by the brachioradialis and in its distal part it is covered only by skin, superficial and deep fasciae. He also stated that sometimes RA lies superficial to the deep fascia.

Sachs M et al[44] (2002) observed the superficial course of RA in anatomical snuff box in 0.87% of specimens.

Aparna G et al[2] (2014) reported a case of radial artery passing superficial to the tendons of anatomical snuff box.

In the present study , course of RA was normal in all the specimens (100%). Superficial course of RA was not found. Cutaneous and Muscular branches are given off from the RA in the lateral aspect of forearm.

RA is easily accessible for interventional and diagnostic procedures as most of its course in forearm is superficial which is normally deep to deep fascia.

In its course, RA is not closely related to any neurovascular structures in forearm. Also the collateral blood supply by the UA in the hand, makes it suitable for invasive procedures like catheterisation and grafting[47].

Superficial course of RA in the CF may be mistaken for vein and is more dangerous during median cubital vein puncture. Accidental intraarterial injections will lead to arterial spasm and even gangrene of hand. Superficial course of RA in forearm is more prone for injuries.

Reconstruction of mandible and thumb is done using the radius. The bony flap is vacularised by the muscular branches of RA. The radius is harvested from the insertion of pronator teres proximally to the insertion of brachioradialis distally. Hence the knowledge about the course of RA is important.

3.LENGTH OF RADIAL ARTERY

Nasr AY[34] (2012) in his study, observed the mean length of RA as 21.6 cms.

Prakash K G et al[40] (2014) found the mean length of RA as 20.63 cms.

Nitin R Mudiraj et al[35] (2015), observed that the mean length of RA was 21.65 cms.

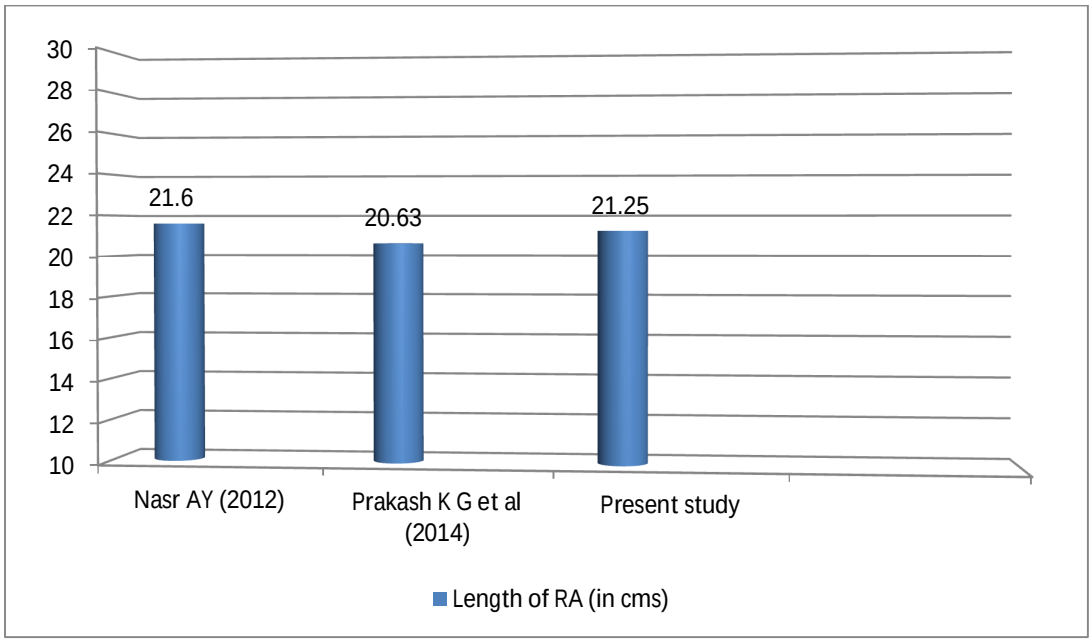
In the present study the mean length of RA was 21.25 cms.(Table no:10)

Entire length of RA from origin to styloid process will be harvested for CABG as arterial length needed for the surgery is around 20cms.

Table No : 10 Mean length of RA (in cms)

Name of the studies	Mean length of RA (in cms)
Nasr AY (2012)	21.60
Prakash K G et al (2014)	20.63
Present study	**21.25**

Chart No : 9 Mean length of RA (in cms)



4.BRANCHES OF RADIAL ARTERY

a).RECURRENT RADIAL ARTERY(RRA)

G J Romanes[18] (1972) in his book, Cunninghams textbook of anatomy has stated that RRA usually arises from the RA and sometimes it may arise from BA or UA. He also stated that accessory RRA may arise from the proximal part of RA.

Gupta C et al[21](2012) observed that 12% of RRA arose from BA in CF.

Atsumori Hamahata A et al [3](2012) observed that 94.4% of RRA arose from RA and 5.6% of RRA arose from UA in CF.

Vazquez T et al[63] (2013) stated that RRA arose from the RA in 75% of specimens. Accessory RRA was present in 2.7% of specimens.

Prakash et al[40] (2014) in their study stated that RRA arose from the RA in 78%, from BA in 18% and from UA in 4% of specimens.

In the present study 96% of RRA arose from the RA and in 4% it arose from the UA and no RRA arose from BA. Accessory RRA was present in 4% of specimens(Table no:11). Findings in the present study coincide with study done by Atsumori Hamahata A et al (2012), Prakash et al (2014) and Vazquez T et al (2013).

As the anastomosis around elbow is well developed, RRA based flap is used for Microsurgical and reconstruction procedure around elbow. Survival of RRA flap is high. Presence of Accessory RRA has an additional advantage during harvesting of the flap.

Table no:11 Origin of RRA and Presence of Accessory RRA

RRA		Gupta C et al(2012)	Atsumori Hamahata A et al (2012)	Vazquez T et al (2013)	Prakash et al (2014)	**Present study**
Origin	**From RA**	86.7%	94.4%	75%	78%	**96%**
	From UA		5.6%	--	4%	**4%**
	From BA	12%	--	--	18%	**--**
Accessory RRA		---	--	2.7%	--	**4%**

Chart No: 10 Origin of RRA

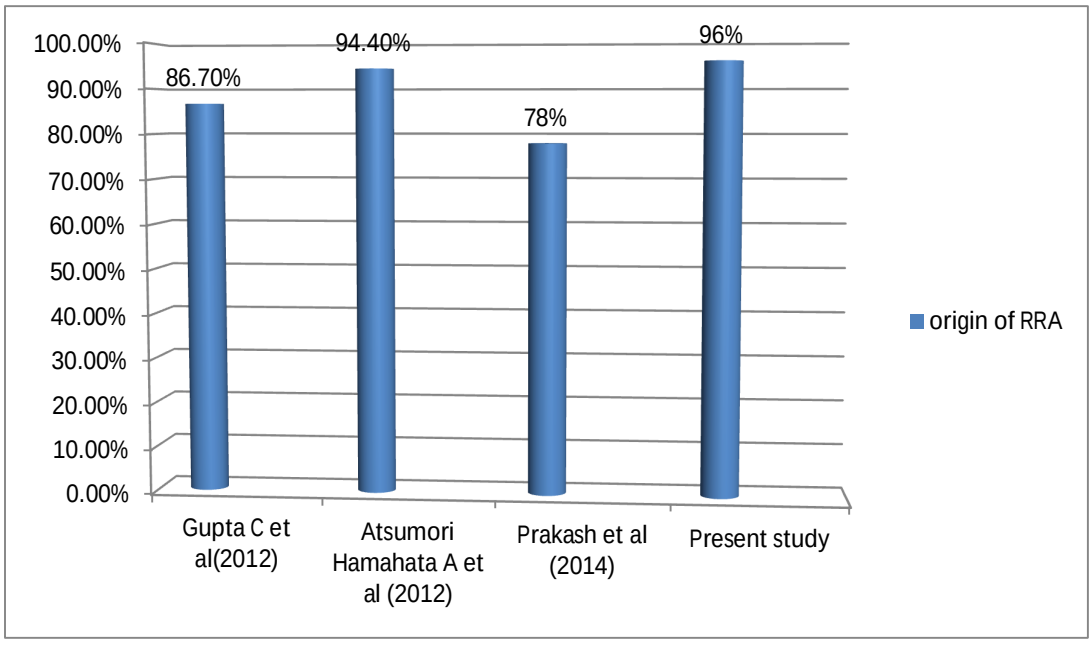
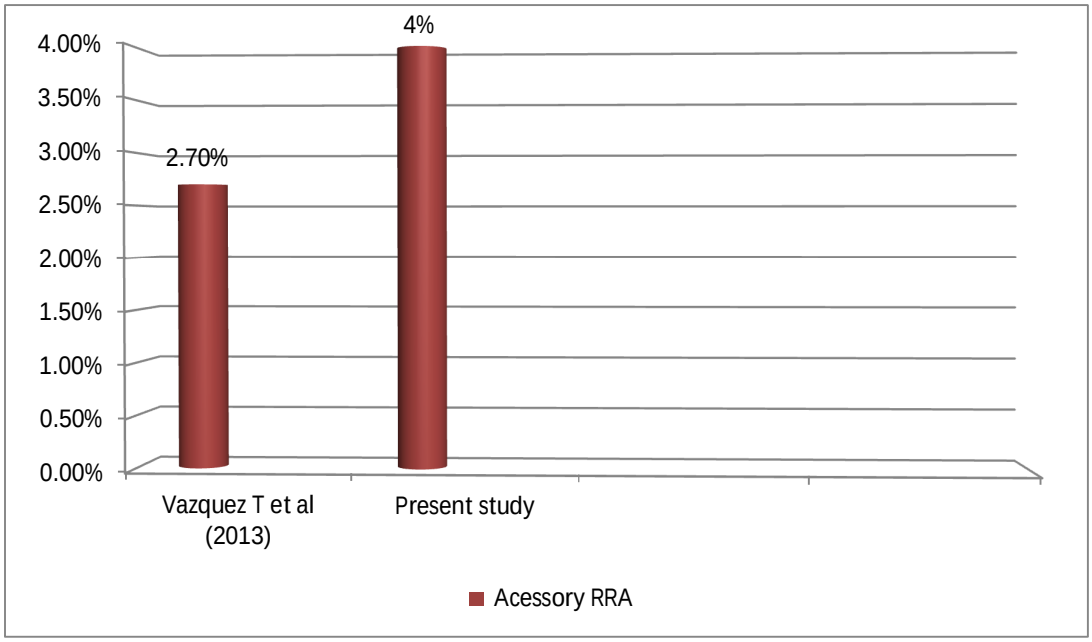


Chart No :11 Presence of Accessory RRA



b). SUPERFICIAL PALMAR BRANCH (SPB)

Marios Loakas et al[31] (2005) reported that 36% of SPA was completed by the SPB of RA and 35% of SPB ends by supplying the thenar muscles.

Suleyman et al[56] (2007) observed that, SPB of RA participates in the formation of SPA in 40%, ends by supplying the thenar muscles in 35%, ends by dividing into APP and ARI in 5% and ends by dividing into common digital arteries for the 1st and 2nd web space in 20% of specimens.

Madhyastha et al[30] (2011) stated that 95.74% of SPB takes part in the formation of SPA, 2.08 % of SPB ends by supplying the thenar muscles and in 2.08% it divides into two common digital arteries for the first two web spaces.

Gupta C et al[21] (2012) observed the absence of SPB of RA in 5.3%, SPB of RA ends by dividing into APP and ARI in 2.7%, ends by supplying the short muscles of thumb in 5.5% and it completes the SPA in 86.5% of specimens.

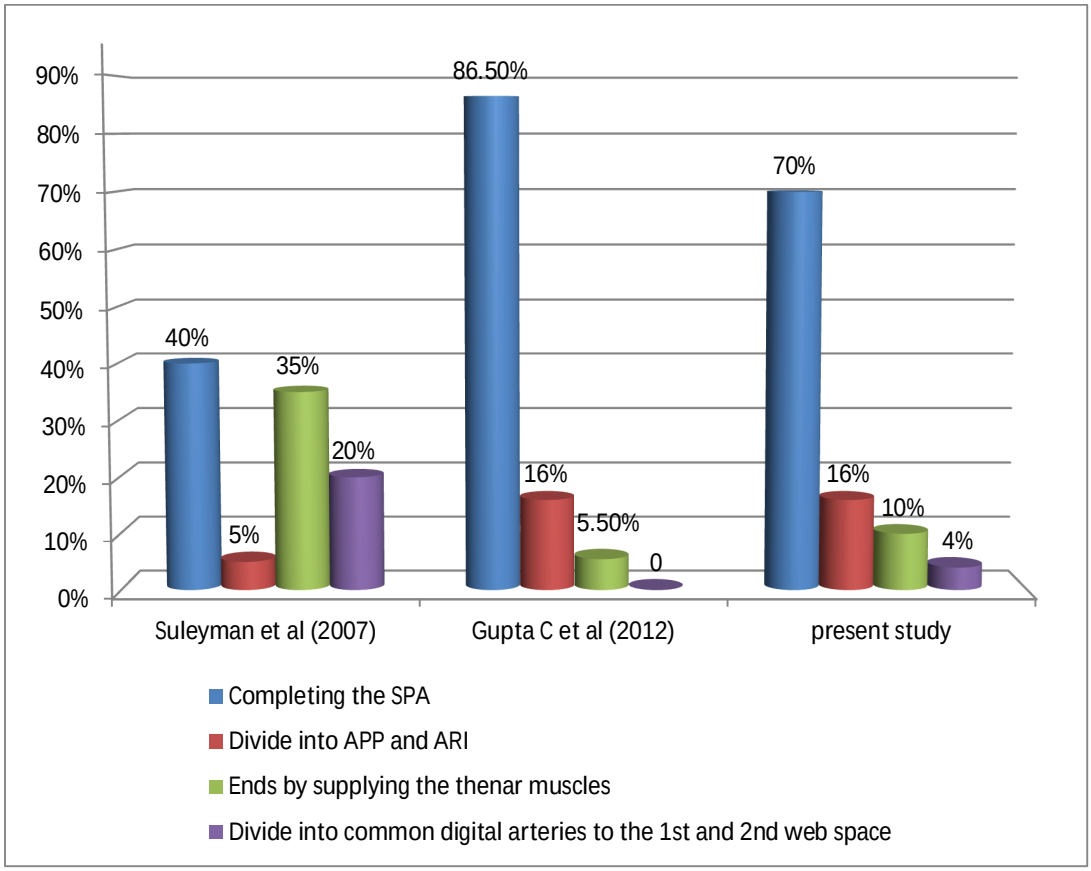
In the present study SPB of RA ends by anastomosing with the UA to form SPA in 70%, divides into APP and ARI in 16%, as a slender branch ends by supplying the thenar muscles in 10% and divides into common digital arteries to the first two web spaces in 4%, which is similar to the studies done by Madhyastha et al (2011) and Gupta C et al (2012). (Table no:12)

RA is the third most commonly used graft next to right and left internal mammary artery for CABG. If the SPB of RA does not complete the SPA, harvesting the RA will lead to loss of blood supply to the thumb resulting in gangrene. Knowledge about the termination of SPB of RA is essential before harvesting the RA for CABG[27].

Table No : 12 Mode of termination of SPB of RA

Mode of termination of SPB	Suleyman et al (2007)	Madhyastha et al (2011)	Gupta C et al (2012)	**Present study**
Completing the SPA	40%	95.74%	86.5%	**70%**
Divide into APP and ARI	5%	--	16%	**16%**
Ends by supplying the thenar muscles	35%	2.08%	5.5%	**10%**
Divide into common digital arteries to the 1^{st} and 2^{nd} web spaces	20%	2.08%	--	**4%**

Chart No. : 12 Mode of termination of SPB of RA



c).ARTERIA PRINCEPS POLLICIS(APP) AND ARTERIA RADIALIS INDICIS(ARI)

J E Frazer[17] (1937) has stated that APP and ARI arose from the Superficial Palmar Arch (SPA) or from the radial side of Deep Palmar Arch (DPA).

Gellman et al[19] (2001) stated that APP and ARI are the terminal divisions of SPB in 11.1% of specimens.

Suganthy J et al[53] (2002) reported a case of APP and ARI arising from the anterior interosseous artery associated with the absence of RA.

Marios Loakas et al [31](2005) in their study stated that 39.5% of APP a nd ARI arose from the SPA(formed by the RA and UA) and 31.5% of APP and ARI arose as common trunk from SPA entirely formed by UA.

Suleyman et al[56] (2007) observed that 40% of APP and ARI arose from the SPA formed by SPB of RA and UA, 35% of APP and ARI arose from the SPA formed entirely by UA, 20% arose from the SPB as common trunk from the SPB of RA and 5% arose as the terminal branch of SPB.

Sujatha Salgado et al[55](2009) in their study stated that 55.5% of APP and ARI arose from SPA(formed by the RA and UA), 33.3% arose from SPA formed by the UA alone and 11.17% arose as the terminal branch of SPB.

Madhyastha et al[30] (2011) observed the orgin of APP and ARI from complete SPA (type I) in 95.93%, from SPA (type II) in 2.08%, from the first common digital artery a branch of SPB of RA in 2.08% of specimens.

Gupta C et al[21] (2012) in his study stated that 2.7% of APP and ARI arose from SPB of RA.

Suman U et al[57] (2013) stated that 50% of APP and ARI arose from complete SPA (type I).

D Srivani[12] (2015) reported a case of APP and ARI arising from the first common digital artery from SPA.

Vidhya Ramakrishnan et al[65] (2014) in their study observed the origins of APP and ARI from SPA (typeI) in 86% and from SPA (typeII) in 6%, as a common trunk (artery to 1st web space) from the SPB in 6% and from the SPB as the terminal branches in 2% of specimens.

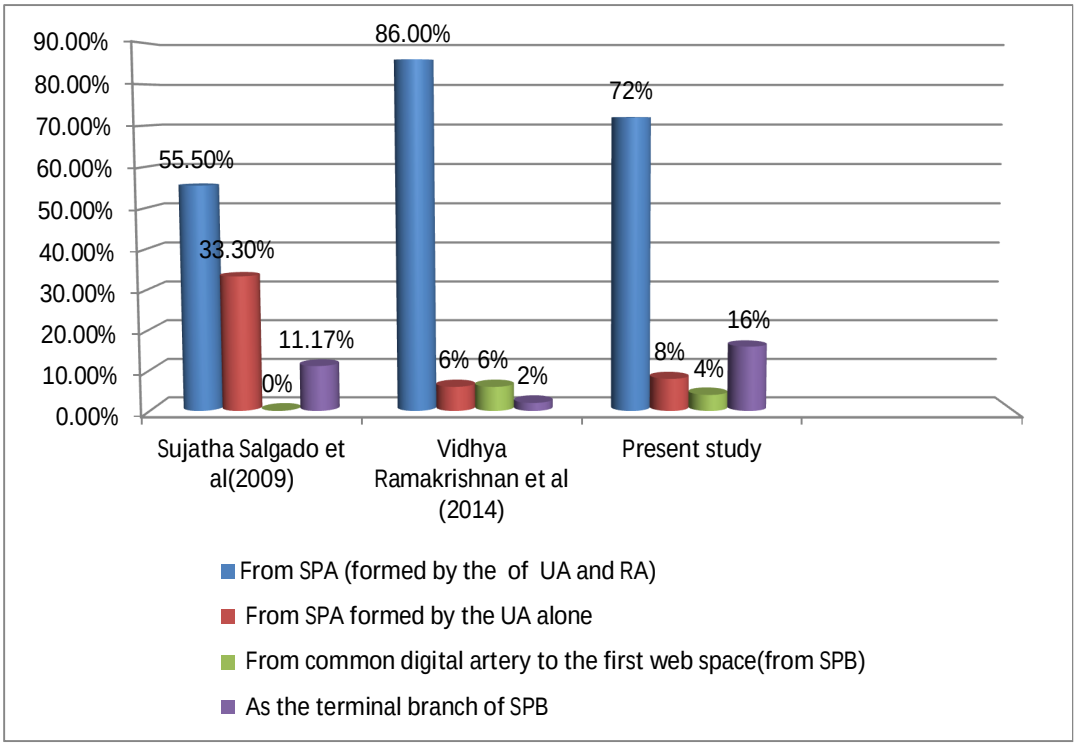
In the present study, APP and ARI arose from the SPA formed by the UA completed by the RA in 72% , from SPA formed entirely UA by in 8%, from SPB of RA(as its terminal branches) in 2%, from the artery to the first web space a branch of SPB in 6% of specimens.(Table no:13)

Blood supply to the thumb and index finger is by the APP and ARI. Grafting of RA is done during CABG. Knowledge about the arterial supply of thumb and index finger is essential before harvesting the RA.

Table No : 13 Origin of APP and ARI

Name of the studies	Marios Loakas et al (2005)	Suleyman et al (2007)	Sujatha Salgado et al(2009)	Vidhya Ramakrishnan et al (2014)	**Present study**
From SPA (formed by the of UA and RA)	39.5%	40%	55.5%	86%	**72%**
From SPA formed by the UA alone	31.5%	35%	33.3%	6%	**8%**
From common digital artery to the first web space(from SPB)	--	20%	--	6%	**4%**
As the terminal branches of SPB	--	5%	11.17%	2%	**16%**

Chart No: 13 Origin of APP and ARI



d).PALMAR CARPAL BRANCH(PCB)

George A Piersol[20] (1930) has stated that PCB of RA arose at the level of wrist joint.

G J Romanes[18] (1972) in his book, Cunninghams textbook of anatomy has stated that the PCB was given off from the RA at the lower border of pronator teres.

Susan Standring[58] (2008) in his book Gray's Anatomy has stated that PCB of RA arose as a small branch of RA at the level of wrist joint and takes part in the formation of anterior carpal arch.

Gupta C et al[21] (2012) in his study observed the absence of PCB in 26.7% of specimens.

Prakash et al[40] (2014) stated that PCB arose from RA at the level of wrist.

In the present study PCB arose from the RA at the level of wrist joint, coursed medially deep to flexor tendons in all the specimens.

PCB of RA participates in the formation of anterior carpal arch[50], any injury around the wrist joint causes severe bleeding and it is necessary to ligate all the arteries participating in the formation of arch.

e).DORSAL CARPAL BRANCH(DCB)

George A Piersol [20](1930) has described the DCB as a slender branch of RA participating in the formation of dorsal carpal arch.

Susan Standring[58] (2008) in his book Gray's Anatomy has stated that DCB of RA arises deep to the tendons of thumb in anatomical snuff box and runs medially to anastomose with the similar branch of UA to form the dorsal carpal arch.

Gupta C et al[21] (2012) in their morphological study of variations and branching pattern and termination of RA, stated that DCB was present in all the specimens.

Prakash et al[40] (2014) reported that DCB of RA arose at the level of wrist joint.

In the present study, in all the specimens DCB arose from the RA deep to the tendons of anatomical snuff box.

Arterial anastomoses around wrist joint may cause heavy bleeding in case of injury[43]. Ligation of all the arteries taking place in anastomoses is essential to control the bleeding.

f).FIRST DORSAL METACARPAL ARTERY(DMA)

G J Romanes[18] (1972) in his book, Cunninghams textbook of anatomy has stated that DMA was replaced by perforating branches from the dorsal carpal arch.

Susan Standring[58] (2008) in his book Gray's Anatomy has stated that DMA arises from the second part of RA before the artery dips between the two heads of first dorsal interosseous muscle.

Jiji P J et al[26] (2009) reported a case of first DMA completing the SPA.

Gupta C et al[21] (2012) stated that in 9.3% of specimens first DMA was absent.

Prakash et al[40] (2014) stated that DMA arose from second of RA in the dorsal aspect of hand.

In the **present study,** first DMA arose from the RA in the dorsal aspect of hand in all upper limbs, which is similar to the studies mentioned above.

First DMA based flaps is used for the reconstruction of thumb in crush injuries as it has a subcutaneous course.

The nutrient artery to the first metacarpal bone is a branch from the first DMA, so injury of the artery may lead to avascular necrosis of the bone. Hence the knowledge about the origin and the course of FDMA is important.

g).ANY OTHER ARTERIES FROM RA

Baral P et al[4] (2002) stated that CIA arose from RA in 12.7% of specimens.

Biloid A K et al[6] (2004) reported that a case of CIA was given off from the RA on CF.

Susan Standring[58] (2008) in his book Gray's Anatomy has stated that (Common Interosseous Artery) CIA may sometimes arise from the RA in CF.

Abid A Angsteen et al[1] (2011) reported a case of CIA arising from RA at the level of elbow joint.

Prakash (2011) K Get al [40] reported a case of CIA arising from the RA along with the anterior and posterior ulnar recurrent arteries.

Sharadhakumar[47] (2013) in his study observed the origin of CIA from RA in 0.5% of .

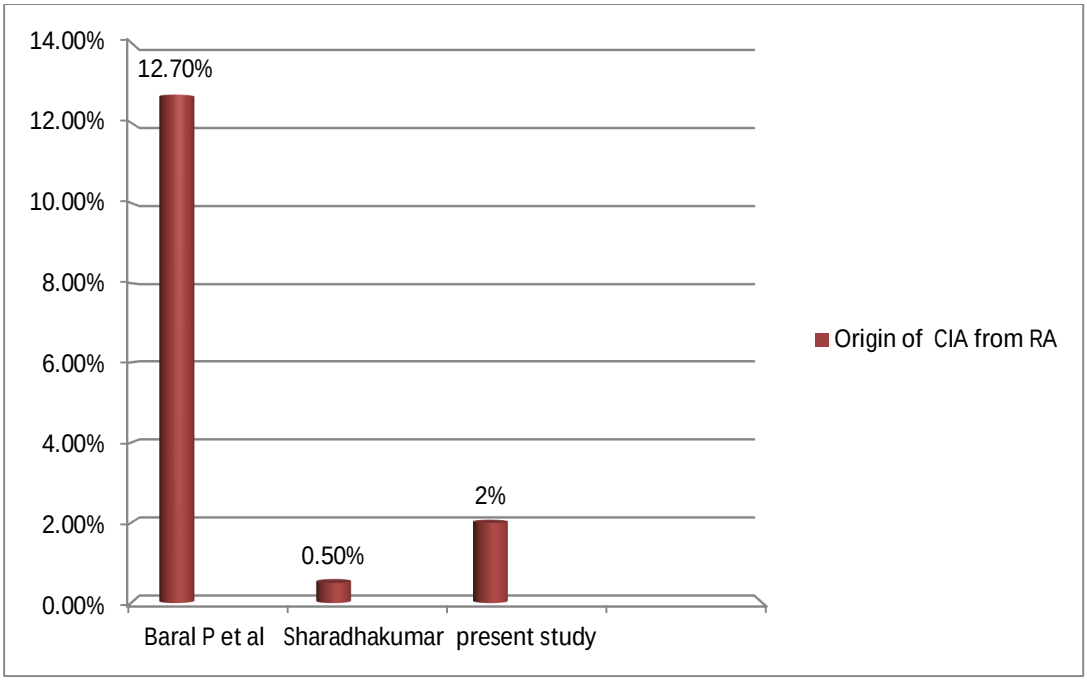
In the present study 2% of CIA arose from the proximal part of RA.**(Table no:14)**

Knowledge about such variation are important during invasive and non-invasive investigative procedures, orthopaedic, reconstructive and surgical procedures to avoid unnecessary complications.

Table No : 14 Origin of CIA from RA

Name of the Studies	Origin of CIA from RA
Baral P et al (2002)	12.7%
Sharadhakumar (2013)	0.5%
Present study	**2%**

Chart No : 14 Origin of CIA from RA



5. COMPLETION OF SUPERFICIAL PALMAR ARCH (SPA) BY RADIAL ARTERY

J E Frazer[17] (1937) has stated that SPA was completed by the SPB of RA. If it fails to complete the SPA , branch from APP or ARI may complete the arch.

J Parsons Schaeffer[39] (1942) has stated that SPA was completed by the SPB of RA anastomosing with the corresponding branch of UA.

Emanuel B Kaplan[14] (1953) has mentioned that, 66% of SPA was formed by UA alone, 30% of SPA was formed by the anastomosis of SPB of UA and RA and in 4% os cases, median artery contributes to the formation of arch.

Coleman SS, Anson BJ[10] (1961) reported the incidence of complete SPA in 78.5% and incomplete arch in 21.5% of specimens. Complete SPA was further sub typed into type I- 34.5%, type II – 37%, type III -3.8%, type IV - 1.2% and type V - 2%.

- Incomplete SPA was further sub typed into type I- 13.4%, type II- 3.2%, type III- 3.8% and type IV – 1%

Suganthy J et al[53] (2002) reported a case of absent RA and SPA.

Marios Loakas et al[31] (2005) in their study reported 90% of complete arch and 10% of incomplete arch. Of the complete arches described, it was observed that 36% belonged to type I,31.5% belonged to type II,13.5% belonged to type III, 6.1% belonged to type IV and 3.5% belonged to type V.

Suleyman et al[56] (2007) in their study reported 75% complete arches and 25% incomplete arches.

- In complete arches, 40% belonged to type I and 35% belonged to type II.
- In incomplete arches,20% and 5% belonged to type I and type II respectively.

Madhyastha et al[30] (2011) observed the complete arch in 97.91% of specimens and incomplete arch in 2.08% of specimens.

Among the complete arches described 95.83% was type I and 2.08% was type II and in Incomplete arches 2.08% was type I.

Gupta C et al[21] (2012) stated that SPA was completed by SPB of RA in 86.5% of specimens.

Vidhya Ramakrishnan et al[65] (2014) stated that SPA was complete in 92% and incomplete in 8% of specimens.

- Among the complete arches described, it was observed that, 86% was type I and 6% was type II .

- Among the Incomplete SPA described it was observed that,6% were type I and 2% were type II.

In the present study, 80% of specimens showed complete arch and 20% of specimens showed incomplete arch.(Table:15)

Among the complete arches, type I was 70%, type II was 8% and type V was 2%. Type II and IV were not observed in the present study.

Of the incomplete arches, type I was 4% and type II was 8%. Type III and IV were not observed in the present study.

Injury to the SPA can compromise the arterial supply of the fingers, especially if there is an insufficient anastomosis between the RA and UA[33,57].

Knowledge about the arterial arches of hand is important during the microsurgical procedures in hand reconstructions and harvesting of the RA for CABG[52,62].

Hence it is mandatory to investigate the arterial pattern of hand before any invasive procedures.

Table No : 15 Completion of Superficial Palmar Arch (SPB) by Radial Artery

Types of SPA		Coleman SS, Anson BJ (1961)	Suleyman et al (2007)	Vidhya Ramakrishnan et al (2014)	**Present study**
Complete arch	Type I	34.5%	40%	86%	**70%**
	Type II	37%	35%	6%	**8%**
	Type V	2%	-	-	**2%**
Incomplete arch	Type I	13.4%	20%	6%	**4%**
	Type II	3.2%	5%	2%	**8%**

Chart No: 15 Complete SPA

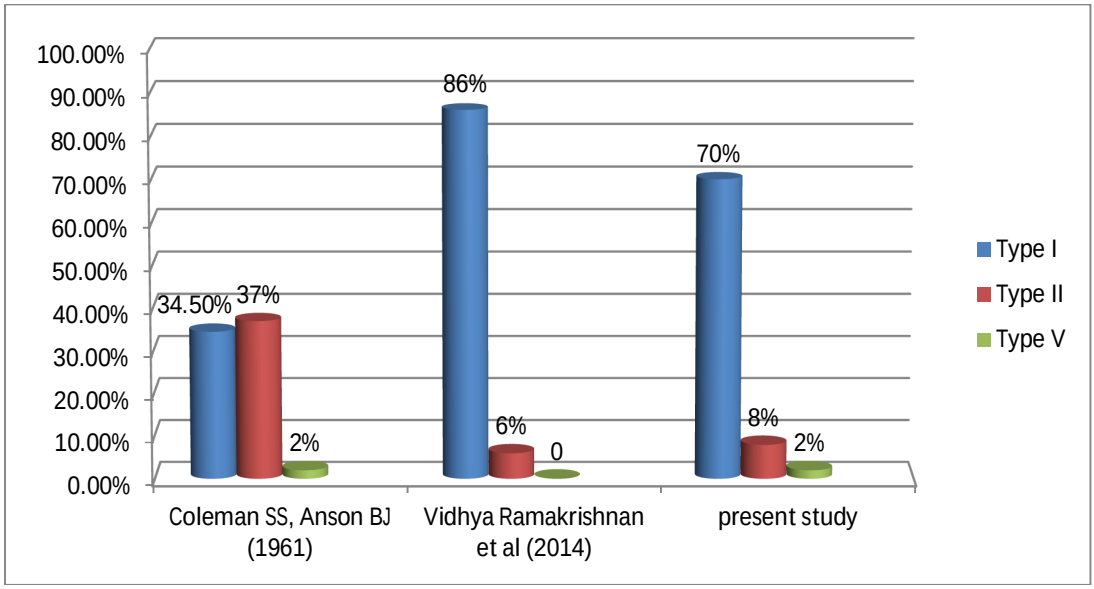
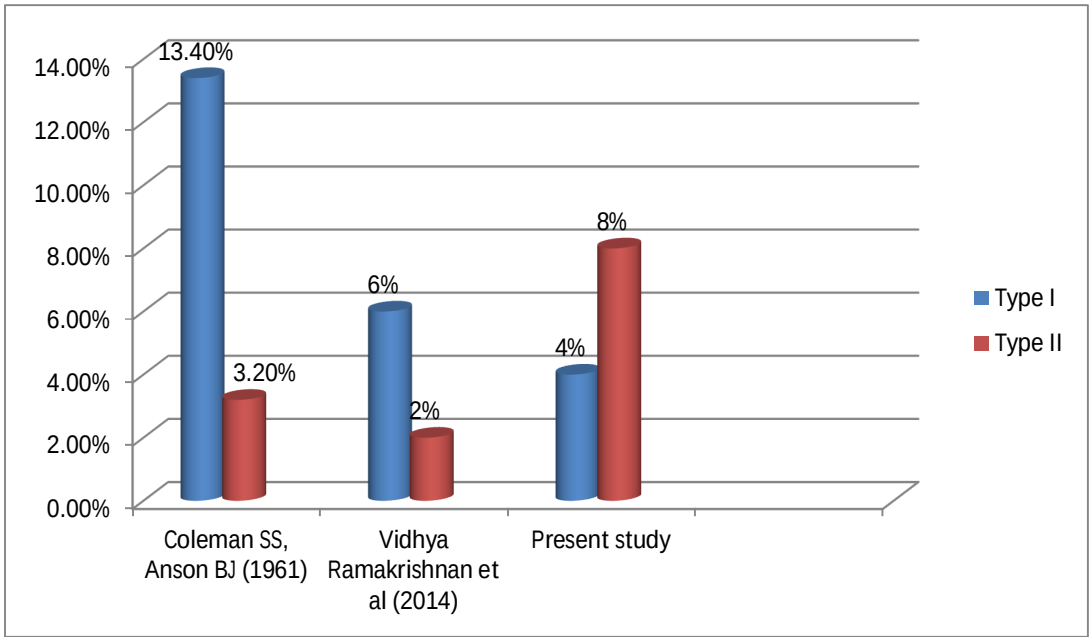


Chart No: 16 Incomplete SPA



7. FORMATION OF DEEP PALMAR ARCH(DPA)

Prof. Johnston[42] (1921) in his book regional anatomy stated that DPA is the continuation of RA into the palm and the arch is completed medially by the deep branch of UA.

Emanuel B Kaplan[14] (1953) has stated that anastomosis between the RA and deep palmar branch of UA forms the DPA. In the absence of RA, anterior interosseous artery takes part in the formation DPA.

Gellman et al[19] (2001) stated that DPA is formed by deep volar branch of RA in all the specimens.

Marios Loakas et al[31] (2005) in their study stated that RA forms the DPA by anastomosing with the deep palmar branch of UA.

Susan Standring[58](2008) in his book "Gray's anatomy" has stated that RA anastomoses with the deep branch of UA to form the DPA at the level of base of metacarpal. Rarely the DPA is incomplete.

Mookambica et al[32](2010) reported a case of DPA formed by the UA without contribution from the RA.

In the present study, DPA was present in all specimens and the RA contributed to the formation of arch.

Any injury in hand will bleed profusely and heal quickly, as hand is richly supplied by the arterial arches. Knowledge about the blood supply of hand is essential during microsurgical hand reconstructive procedures for safe and successful outcomes.

Conclusion

CONCLUSION

The Radial artery and its branching pattern have been of great interest to anatomists and surgeons, due to wide clinical and radiological implications. Present study was done to document and provide information of both normal and variant morphology of the radial artery in adult human cadavers by dissection method. The following conclusions were drawn.

- The origin of Radial artery was from the Brachial artery in cubital fossa in 94% of specimens and from the Brachial artery in arm in 6% of specimens.
- The mean length of Radial artery was 21.25 cm and no anomalous course of radial artery was observed.
- The Recurrent radial artery arose from the radial artery in 96% of specimens and from the brachial artery in 4% of specimens. Accessory recurrent radial artery was present in 4% of specimens.
- Superficial palmar branch of radial artery completed the superficial palmar arch in 70%, divided into arteria princeps pollicis and arteria radialis indicis in 16% , ended by supplying the thenar muscles in 10% and by branching into common digital arteries to the first two web spaces in 4% of specimens.

- Arteria princeps pollicis and Arteria radialis indicis arose from the superficial palmar arch (type I) in 72%, from the superficial palmar branch of radial artery (type II) in 8%, from the common digital artery to the first web space in 4% and as the terminal branches of superficial palmar branch of radial artery in 16% of specimens.

- Palmar carpal branch, dorsal carpal branch and first dorsal metacarpal branch was present in all the specimens.

- Common interosseous artery arose from the radial artery in 2% of specimens.

- Complete and incomplete superficial palmar arch was found in 80% and 20% of specimens respectively. This classification was done based on the Coleman and Anson's classification of superficial palmar arch.

- In complete arch, 70% belonged to type I, 8% belonged to type II and 2% belonged to type V.

- In incomplete arch, 4% belonged to type I and 16% belonged to type II.

- The deep palmar arch was formed by the radial artery in all the specimens.

There were variations with respect to the origin, course and branching pattern of the radial artery in the present study. Such variations have clinical importance in the field of vascular surgeries like CABG, orthopaedic surgeries, plastic and reconstructive surgeries.

The superficial palmar arch is the centre of attraction for most of the procedures in forearm and hand, as the healthy functioning of the arch is necessary in order to maintain the perfusion of hand and digits. Techniques like Doppler ultrasound and arterial angiography can be used to identify the arterial pattern of hand before proceeding for any invasive and interventional procedures.

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MASTER CHART

S.No	Site of origin of RA from BA in	Length of RA	Course of RA	Origin of RRA	Presence of accessory RRA	Mode of termination of SPB of RA	Origin of PCD & DCB	Origin of FDMA	Origin of APP and ARI	Completion of SPA by RA	Formation of DPA by
1.	CF	22.5	N	RA	A	Completes the SPA	RA	RA	SPA by RA & UA	C SPA TYPE I	RA
2.	CF	22.7	N	RA	A	Completes the SPA	RA	RA	SPA by RA & UA	C SPA TYPE I	RA
3.	CF	21	N	RA	A	Completes the SPA	RA	RA	SPA by RA & UA	C SPA TYPE I	RA
4.	CF	22	N	RA	A	Completes the SPA	RA	RA	SPA by RA & UA	C SPA TYPE I	RA
5.	CF	20	N	RA	A	Divides into APP & ARI	RA	RA	From SPB of RA	IC SPA TYPE I	RA
6.	CF	21	N	RA	A	Completes the SPA	RA	RA	SPA by RA & UA	C SPA TYPE I	RA
7.	CF	21	N	RA	A	Completes the SPA	RA	RA	SPA by RA & UA	C SPA TYPE I	RA
8.	CF	21	N	RA	A	To TM	RA	RA	SPA formed by UA	C SPA type II	RA
9.	CF	20	N	RA	A	Completes the SPA	RA	RA	SPA by RA & UA	C SPA TYPE I	RA
10.	CF	20	N	RA	A	Completes the SPA	RA	RA	SPA by RA & UA	C SPA TYPE I	RA
11.	CF	21.2	N	RA	A	Divides into APP & ARI	RA	RA	From SPB of RA	IC SPA TYPE I	RA
12.	CF	20	N	RA	A	A to 1^{st} &2^{nd} web spaes	RA	RA	From A to 1^{st} web space	IC SPA TYPE II	RA
13.	CF	21	N	UA	A	Completes the SPA	RA	RA	SPA by RA & UA	C SPA TYPE I	RA
14.	ARM	28	N	RA	P	Completes the SPA	RA	RA	SPA by RA & UA	C SPA TYPE I	RA
15.	CF	22	N	RA	A	Divides into APP & ARI	RA	RA	From SPB of RA	IC SPA TYPE I	RA
16.	CF	21.5	N	RA	A	Completes the SPA	RA	RA	SPA by RA & UA	C SPA TYPE I	RA
17.	CF	22	N	RA	A	To TM	RA	RA	SPA formed by UA	C SPA type II	RA
18.	CF	23	N	RA	A	To TM	RA	RA	SPA formed by UA	C SPA type II	RA
19.	CF	22.3	N	RA	A	Completes the SPA	RA	RA	SPA by RA & UA	C SPA TYPE I	RA

S.No	Site of origin of RA from BA in	Length of RA	Course of RA	Origin of RRA	Presence of accessory RRA	Mode of termination of SPB of RA	Origin of PCD & DCB	Origin of FDMA	Origin of APP and ARI	Completion of SPA by RA	Formation of DPA by
20.	CF	22	N	RA	A	Completes the SPA	RA	RA	SPA by RA & UA	C SPA TYPE I	RA
21.	CF	21	N	RA	A	Divides into APP & ARI	RA	RA	From SPB of RA	IC SPA TYPE I	RA
22.	ARM	29	N	RA	A	Completes the SPA	RA	RA	SPA by RA & UA	C SPA TYPE I	RA
23.	CF	21.7	N	RA	A	Completes the SPA	RA	RA	SPA by RA & UA	C SPA TYPE I	RA
24.	CF	27	N	RA	A	Completes the SPA	RA	RA	SPA by RA & UA	C SPA TYPE I	RA
25.	CF	22	N	RA	A	Completes the SPA	RA	RA	SPA by RA & UA	C SPA TYPE I	RA
26.	CF	22	N	RA	A	A to 1^{st} &2^{nd} web spaces	RA	RA	From A to 1^{st} web space	IC SPA TYPE II	RA
27.	CF	23.7	N	RA	A	Completes the SPA	RA	RA	SPA by RA & UA	C SPA TYPE I	RA
28.	CF	22.9	N	RA	A	Completes the SPA	RA	RA	SPA by RA & UA	C SPA TYPE I	RA
29.	CF	20	N	RA	A	Completes the SPA	RA	RA	SPA by RA & UA	C SPA TYPE I	RA
30.	CF	22.1	N	UA	A	Completes the SPA	RA	RA	SPA by RA & UA	C SPA TYPE I	RA
31.	CF	22	N	RA	A	Completes the SPA	RA	RA	SPA by RA & UA	C SPA TYPE I	RA
32.	ARM	21.4	N	RA	A	Divides into APP & ARI	RA	RA	From SPB of RA	IC SPA TYPE I	RA
33.	CF	22	N	RA	A	Completes the SPA	RA	RA	SPA by RA & UA	C SPA TYPE I	RA
34.	CF	21	N	RA	A	Completes the SPA	RA	RA	SPA by RA & UA	C SPA TYPE I	RA
35.	CF	21	N	RA	A	Completes the SPA	RA	RA	SPA by RA & UA	C SPA TYPE I	RA
36.	CF	22	N	RA	A	Divides into APP & ARI	RA	RA	From SPB of RA	IC SPA TYPE I	RA
37.	CF	21.7	N	RA	A	Completes the SPA	RA	RA	SPA by RA & UA	C SPA TYPE I	RA
38.	CF	21.3	N	RA	A	Completes the SPA	RA	RA	SPA by RA & UA	C SPA TYPE I	RA
39.	CF	19	N	RA	A	Completes the SPA	RA	RA	SPA by RA & UA	C SPA TYPE I	RA
40.	CF	19.8	N	RA	A	To TM	RA	RA	SPA formed by UA	C SPA type II	RA

S.No	Site of origin of RA from BA in	Length of RA	Course of RA	Origin of RRA	Presence of accessory RRA	Mode of termination of SPB of RA	Origin of PCD & DCB	Origin of FDMA	Origin of APP and ARI	Completion of SPA by RA	Formation of DPA by
41.	CF	21	N	RA	P	Completes the SPA	RA	RA	SPA by RA & UA	C SPA TYPE I	RA
42.	CF	21.2	N	RA	A	Completes the SPA	RA	RA	SPA by RA & UA	C SPA TYPE I	RA
43.	CF	21.2	N	RA	A	Completes the SPA	RA	RA	SPA by RA & UA	C SPA TYPE I	RA
44.	CF	20	N	RA	A	Divides into APP & ARI	RA	RA	From SPB of RA	IC SPA TYPE I	RA
45.	CF	20	N	RA	A	Completes the SPA	RA	RA	SPA by RA & UA	C SPA TYPE I	RA
46.	CF	21.4	N	RA	A	To TM	RA	RA	SPA formed by UA	C SPA type II	RA
47.	CF	23	N	RA	A	To TM	RA	RA	SPA by RA & UA	C SPA TYPE V	RA
48.	CF	22	N	RA	A	Completes the SPA	RA	RA	SPA by RA & UA	C SPA TYPE I	RA
49.	CF	18	N	RA	A	Completes the SPA	RA	RA	SPA by RA & UA	C SPA TYPE I	RA
50.	CF	18	N	RA	A	Divides into APP & ARI	RA	RA	From SPB of RA	IC SPA TYPE I	RA

CF- Cubital Fossa N – Normal RA – Radial Artery A – Absent P – present APP- Arteria princeps pollicis ARI- Arteria radialis indicis SPB- Superficial palmar branch C- Complete, IC Incomplete SPA- Superficial palmsar arch